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ABSTRACT

Recorded in this document are hearings before the Committee on Science and Technology (U.S. House of Representatives). The central issues addressed in the hearings were whether the need for long-term steadiness in technology investment is holding its own against short-term budget expendiencies, and in particular, whether the budget stress is upsetting the government-university and government-industry relationships which had catapulted this country into postwar technological leadership. Following testimony by George A. Keyworth II (Director, Office of Science and Technology, Executive Office of the President) on President Reagan's science policy, additional testimony was provided by college presidents, scientists, and representatives of government and industry, addressing both general issues and those directly related to their specific areas. For example, impacts of budget cuts on science and technology programs, graduate study, and research facilities/equipment were among the issues addressed by the college presidents. Prepared statements by witnesses and a summary report (supplementing testimony of Frank Press, President, National Academy of Sciences) of a conference on research and development budget for 1982 and future years are included. (JN)

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U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS

HEARINGS

BEFORE THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-SEVENTH CONGRESS
FIRST AND SECOND SESSIONS

DECEMBER 10, 1981; FEBRUARY 2, 3, 4, 1982

[No. 118]

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*On assignment to Budget Committee for 97th Congress.

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U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS

THURSDAY, DECEMBER 10, 1981

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Mr. Fuqua. The committee will be in order.

I would like to welcome our distinguished witnesses today and thank all those in the audience for their support of efforts to sustain the scientific and technical vitality of this country through this period of budget stress.

I, personally, have strong respect for the President's determination to break the spiral of inflation. I have supported his notion that strong Federal budget restraint was a means to achieve this end. I have even understood his sense that expectations had to be changed suddenly and dramatically.

However, there are crucial long-range considerations which go beyond the shifting politics of this year's budget deficit. This committee's special stewardship for the Nation's science and technology enterprise has taught us that there will be budget issues before the Congress in which the long-range considerations should weigh as heavily as in science and technology. Preserving continuity in the progress of scientific knowledge and in the development of technology is an investment in the future. This investment has proven over and over to offer payoffs beyond our wildest dreams.

This is, of course, where the President's goals of strengthening this Nation's security, enhancing its productivity, and building its innovative capability clash with his goal of sudden change in budgetary assumptions.

We must insist on a reasonable balance among those goals. There will be no security or leadership in a technological world for a nation that is willing, for short-term expediency, to interrupt the training and careers of its most talented scientists and engineers, or abandon its most promising technical endeavors.

Today, the committee is beginning its inquiry as to whether the administration, through budget and other actions, is striking the appropriate balance. We will continue this with further hearings in February and through the budget authorization process next year. We will work closely with our Senate colleagues who share our concern for the vitality of science and technology.

I feel confident that the recognition of the need to inject long-range thinking into the short-range budget number juggling will be recognized on a bipartisan basis.

We will place heavy reliance on the advice of the country's scientific and technological leadership in this process. They know as well as we do that budget stress is a fact of life, and that untempered or self-serving demands will have little credibility.

However, initiatives like that of Dr. Press in convening the unprecedented October National Academy meeting on science budgets are of enormous value to us. The process started there will help us realistically assess the extent of damage to the health of science and technology, and seek ways to avoid and repair in the future.

The central question of our hearings is whether the need for long-term steadiness in technology investment is holding its own against short-term budget expediencies. There are some who say that there is evidence building that indicates the answer is "No."

We have heard many anguished voices claiming that current actions and policies are disrupting proven national laboratories and interrupting promising and productive programs.

We want to know whether the budget stress is upsetting the very Government-university and Government-industry relationships which had catapulted this country into undreamed of postwar technical leadership.

Our witnesses today care about the health of science and technology as much as any in this country. I am hoping that they will be able to guide us as to whether our fears are justified or exaggerated.

I hope also that they will be able to advise us on ways we can insulate the long-range integrity of our scientific and technological progress from the rapidly changing budget politics and theories which seem so often to dominate the political stage.

Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman.

Mr. Chairman, I want to join you in welcoming our distinguished witnesses here today. I must confess that I don't feel that the title "U.S. Science and Technology Under Budget Stress" is an entirely appropriate caption for this hearing.

It implies that some sort of catastrophe has struck U.S. science and technology. This is simply not the case. Perhaps a more appropriate title would be "U.S. Science and Technology Within a New Federal Philosophy."

I have had an opportunity to review Dr. Keyworth's statement this morning and I want to congratulate him—in advance—for it. It is a very thoughtful statement on the administration's philosophy on science and technology policy.

This is the first time in my 15 years in Congress that I can recall any administration so plainly but firmly stating a comprehensive course for our Nation's science policy. Frankly, it is long overdue.

During this long interval, an attitude has prevailed that the more Federal tax dollars spent on science, the higher the quality of science we receive. This has not proven to be true.

Some have felt that science research and its share of the Federal budget could operate in a vacuum. This, also, has proven false.

Instead, it is now apparent that support for science and technology is undeniably bound to the health of the national economy as a whole. The comprehensive policy that Dr. Keyworth is presenting today reflects this prudent view.

Certainly the changes in longstanding policy being proposed by the administration are startling in their boldness. But there is no reason to reject them out of hand. That is why I am concerned with the attitudes being displayed by some of my colleagues in the House.

Some in the House seem intent upon sponsoring a series of hearings designed to attack the boldness of the administration budget initiatives. This has been spread across almost all committees of the House.

I trust that this meeting today will not fall into that category and that we will give an impartial hearing to a new comprehensive approach to science policy.

Mr. Chairman, I look forward to the testimony from our distinguished witnesses today and trust that they will provide us with some fresh insights as to how a creative science policy can mesh with the new economic realities of our Nation today.

Thank you, Mr. Chairman.

The **Chairman**. Thank you, Mr. Winn.

[Without objection the statements of Mr. Walgren, Mr. Brown, Mr. Hollenbeck, and Mrs. Schneider will be included in the record at this point:]

STATEMENT OF HON. DOUG WALGREN

I join in commending you, Mr. Chairman, for taking the initiative to hold this important hearing.

Over the last nine months, the Congress has worked hard on the President's budget, including the extensive changes sent up in March and again in September. We have devoted much time to the questions of the economy and economic policy in general. And, we have also devoted many hours to specific issues and questions concerning individual Federal programs, including the many science and technology programs of the different agencies which perform and support research and development.

The one thing which has not, in my view, received sufficient attention is this Administration's overall policy for science and technology. While we have been concerned with the specific impacts of the many and varied cuts which the President has proposed, we have not sufficiently analyzed their cumulative effects. And, while we have dealt with the short-term effects of the proposed cuts, we have not examined in depth their long-term implications for the Nation's leadership position in science and technology. As Chairman of the Subcommittee with oversight responsibility for the Office of Science and Technology Policy, I am personally concerned that the Administration itself may not have done a sufficiently careful analysis of these broader issues.

Today's discussion with the OSTP Director, the National Academy of Science President, and the former OSTP and NSF Director is exactly the right forum for such an examination. I look forward to hearing the views of the distinguished witnesses which chairman Fuqua has brought before us today, and to participate in the discussion of the vital questions which the drastic budget cuts necessarily raise for all of us in the Congress.

STATEMENT OF HON. GEORGE E. BROWN, JR.

Mr. Chairman, I am extremely pleased that the Science and Technology Committee today will examine the stresses caused by disruptive mechanisms of this year's budget process on U.S. Science and Technology. I congratulate you for scheduling these hearings and am looking forward to identifying ways of maintaining and promoting a continuous high quality effort in science and technology in this country.

The Reagan Administration's proposals for drastically cutting science and technology R. & D. funding, although devastating in their effects, have forced this Committee, Congress, and the scientific community to examine the broad role and value of science and technology support. Although Congress has clearly not given the Administration the total extent of cuts it sought, the effects have been dramatic, if only in the threat the proposals presented.

In the coming several years it is clear that the Administration will continue to seek more and more cuts. The far-reaching effects of this kind of program should be, and are, at the very foundation of the interests of this Committee.

The United States is suffering economically from its schizophrenia over what the proper role of government is in supporting research, development, and demonstration. The U.S. still has the strongest basic research base in the world, and while this base is threatened by the policies of the Reagan Administration, so too is our economy threatened today by our nation's competitive disadvantage resulting from insufficient support of new technologies.

The termination or curtailment of programs to help U.S. innovation and productivity are an example of a major switch in public policy that has been made without public debate or consent. I believe that the government can be a part of the solution to the needs of society, although I certainly do not wish to indicate blind support for ongoing programs. I hope that no artificial boundaries between the research and development continuum, (basic research, development and demonstration) will be emphasized, lest one part of the scientific and technological enterprise be cannibalized to feed another.

I look forward to addressing some of these issues today, and to a continuing dialog with the scientific community on how best to educate ourselves and the public on the importance of science and technology.

Thank you, Mr. Chairman.

STATEMENT OF HON. HAROLD C. HOLLENBECK

Thank you, Mr. Chairman. I look forward to the testimony today of our three distinguished guests, Drs. Keyworth, Press, and Stever. As the current and former Presidential science advisors, these gentlemen have keen insight on the impact of current budget stress on the health of American science and technology.

As the Ranking Republican on the Space Science and Applications Subcommittee, I am particularly interested in how the recent additional budget cuts will affect our civilian space program. As you know, we recently authorized $6.17 billion for the fiscal year 1982 NASA budget. This budget funds the programs that are the backbone of NASA, namely, development of the Space Shuttle Orbiter, Atlantis; space telescope; various planetary exploration programs including the Galileo orbiter and probe, and the Venus Orbiting Imaging Radar mission; technology utilization and space applications, which have moved a number of NASA-derived spinoffs into the private marketplace; and aeronautical research and technology.

If further budget reductions are to be implemented, then we have to evaluate their impact on various space programs and NASA centers. Our Subcommittee has yet to formally hear how NASA will apply moneys from a substantially reduced budget, however, much speculation has been circulated. The spectulation is alarming and includes: closing the Ames and Lewis Research Centers, abolishing all planetary exploration programs, eliminating the manufacture of a fifth space shuttle orbiter, curtailing all aeronautical research and technology programs and closing the Deep Space Tracking Network; essentially turning off the Voyager spacecraft.

I am sure other members of the Committee feel as I do and hope that the impact will not be as severe as suggested. I for one, simply will not support a budget that will totally destroy past worthwhile efforts and possibly jeopardize continuing noteworthy achievements. I urge all members to carefully consider all implications, including social, economical as well as political as Congress addresses the President's revised budget for fiscal 1982 and beyond. We must use caution and guard against irreparable harm to the United States' leadership position in Science and Technology affairs.

In the current budget climate all agencies involved in U.S. science and technology policy must extensively review all programs. Objectives and goals must be established. By identifying priorities, we will be eliminating programs that have shown questionable returns and results. In turn and perhaps more importantly, we will maximizing our limited manpower and resources to their greatest extent.

Finally, Mr. Chairman, we should remember that with passage of the Economic Tax Recovery Act of 1981, Public Law 97-34, business and industry were provided with new opportunities to invest in science research and development. In these days of fiscal responsibility I call on the private sector to become a leader in support of further scientific advancements.

As a member of the Committee, I stand ready to help establish budget priorities for NASA as well as all other federal agencies involved in science policy formation. Further, I am committeed within the scope of reasonable funding levels to work to maintain and foster excellence in U.S. scientific and technological advancements.

STATEMENT OF MRS. SCHNEIDER

Thank you, Mr. Chairman. I appreciate the opportunity to hear today how the Administration plans to direct our scientific research programs within a limited budget. I believe the Administration's goal—to establish national priorities for the allocation of scarce research dollars—is a good one and deserves support. It is clear that we can no longer afford the haphazard decisionmaking that has characterized federal spending in the past.

However, as Members of the Science Committee, we have two particular responsibilities—we must exercise our own responsible judgment concerning what should be our national priorities for research—then we must determine what budget levels are needed to accomplish the agenda we set forth.

My concern with some of the priorities expressed thus far is no secret. I believe that concentrating almost our entire energy budget in the area of nuclear power at the expense of a wide range of other energy technologies will distort our choices in the future. A balanced energy research program, effectively administered, would be a much better investment for our energy independence and would have the support of the American people. We are reining in our photovoltaics program at the same time the Japanese are accerating their own investment in that technology. The experts agree that we are on the edge of a breakthrough in photovoltaic research—if we give up now, we may be importing that technology from the Japanese in five years.

I am also concerned with the scale of the cutbacks in our civilian research programs, which could put us even further behind our competitors in Japan and West Germany. It is important to remember that more than half our research is for military purposes, while the Japanese and West Germans, for example, are free to concentrate almost all of their research investment in civilian technologies. If we fall further behind in our commitment to civilian research, we may begin to lose the competitive edge that our high technology industries have given us in international trade.

Finally, we must insure that the budgets for our research programs are adequate to support the tasks we assign them. If we want to base our environmental standards on the best available scientific knowledge, we cannot affor to cut in half the research budgets that sustain those standards.

We cannot underestimate the seriousness of our task. Our investment in science is an investment in the future—the decisions we make today will have a profound effect on the choices we have tomorrow.

Without objection, photographs and recordings will be permitted during the hearing.

Our first witness is Dr. George Keyworth, the Director of the Office of Science and Technology Policy, Executive Office of the President.

We are happy to have you back again and would be happy to hear your testimony. I might inform the members that Dr. Keyworth has another appointment later in the morning and we will have to make sure that he is through in time to make that and we will cooperate and get you out on time.

We are happy to hear from you.

[The biographical sketch of Dr. Keyworth follows:]

DR. GEORGE A. KEYWORTH II, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

George A. Keyworth, II was born in Boston, Massachusetts on November 30, 1939. Upon completion of high school in the Boston area he entered Yale University and received his B.S. degree in physics in 1963, went on to pursue his Ph.D. in physics at Duke University which was awarded in 1968.

Dr. Keyworth joined the Los Alamos Scientific Laboratory scientific staff in 1968 and devoted his efforts until 1974 to the development of an experimental program to use polarized pulsed beams of neutrons and polarized targets to study detailed resonance structure in fission. This work represented a major breakthrough in the experimental and theoretical understanding of resonance fission, in addition to providing a new technique for nuclear spectroscopy.

In 1974, Dr. Keyworth embarked upon a path of scientific leadership at Los Alamos concerning development of a comprehensive and imaginative program in weapons physics. He recently received international recognition for his work in this area.

In 1978, he became responsible for the direction of several hundred scientists and technicians whose research encompassed weapons physics, basic research in nuclear and condensed matter physics, astrophysics and space sciences, satellite-based verification of nuclear test treaties and, later, diagnostics of underground nuclear tests conducted at the Nevada Test Site.

In 1980, Dr. Keyworth was appointed Acting Division Leader of the Los Alamos Laser Fusion Division prior to its being combined with the Physics Division, all of which came under his direction, in March, 1981.

While at Los Alamos he served on numerous committees, including: the LAMPF Long-Range Planning Committee; LANL Weapons Data Committee; WNR Program Advisory Committee; DOE Fusion Data Committee; Organizational committees for international conferences in nuclear physics; and the University of California Selection Committee for Director of Los Alamos National Laboratory.

Dr. Keyworth is the author and co-author of some 28 scientific papers. He holds membership in the American Physical Society, the American Association for the Advancement of Science, Signa Xi Honrary Scientific Society, and the Cosmos Club of Washington.

He is listed in American Men and Women in sciences; 12th, 13th, 14th editions, and Who's Who in the South and Southwest.

On May 19, 1981, President Reagan announced his intention to nominate George A. Keyworth, II to be Director of the Office of Science and Technology Policy, Executive Office of the President. The Director serves as Science and Technology Adviser to the President. His appointment was confirmed by a unanimous vote of the Senate on July 24, 1981. He was sworn into office on August 6, 1981.

Dr. Keyworth is married, has two children and resides in McLean, Virginia.

STATEMENT OF DR. GEORGE A. KEYWORTH II, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Dr. Keyworth. Thank you, Mr. Chairman.

I am both pleased and honored to be here today, pleased to have an opportunity to discuss the Reagan administration's science policy with you and honored to appear before this committee with two of my distinguished predecessors.

In its stewardship of Federal support of science and technology, this committee has had a significant impact on the course of our scientific development.

And Frank Press and Guy Stever have each played an important role—not only as science advisors, but throughout their careers.

As you have requested, Mr. Chairman, I would like to present my comments at this time as a summary of a longer statement to be submitted for the record.

Let me begin by making a point that may appear obvious.

Science policy is not made in a vacuum. It is an exercise in priority setting and decisionmaking that must be carried out in the context of other national policies such as those concerning national security, international relations, energy, social services, and the economy.

For example, science policy, made without considering economic policy, is irrelevant. This is especially true in the present administration, where the President's economic recovery program is reversing many policies of longstanding.

This country has been plagued for years by an unacceptable level of inflation, high interest rates and a runaway Federal budget.

Complex and often unnecessary regulations, as well as inadequate incentives to encourage investment and growth in the private sector, have reduced our productivity and international competitiveness.

All of these problems are interrelated, of course, and can be overcome only by a coordinated effort involving tax policy, regulatory policy, fiscal policy and other measures.

Within the context of today's national interests and economic policies, what should be the role of the Federal Government in science and technology?

What should be the framework and guiding philosophy of our national science and technology policy?

Certainly, a science policy for the 1980's cannot be and should not be one based simply on growth for growth's sake. Even in a period of affluence and sustained economic growth, throwing money at problems has not proved to be an effective strategy.

In fact, it has often been responsible for furthering mediocrity rather than stimulating excellence. But, particularly in these times we must sharpen our focus and make a concerted effort to allocate our resources in ways that support the most superior, promising and relevant efforts.

I am proposing a Federal role in R. & D. which is appropriate to the 1980's—appropriate to a national mood which calls for increased vigor and acceptance of responsibility by individuals and organizations in the private sector and decreased involvement by the Federal Government in many of our affairs. This is the direction in which we are moving.

The Reagan administration places great value on our country's scientific and technological strength. Supporting science is a necessity for all great nations, and certainly for the United States.

Success in achieving virtually all of our national goals for the 1980's—more vigorous economic growth, enhanced national security, a stronger competitive position in world markets, better health and quality of life for all our people—will depend in large part on knowledge and technological developments which can come only from scientific research.

We must realize that science and particularly basic research is a critical factor in determining our ability and readiness to meet the problems of the unforeseeable future.

I am firmly convinced that the condition of U.S. science is generally healthy. That health is reflected in the excellent and exciting research taking place in many diverse fields, such as high energy physics, agricultural sciences, astronomy, geophysics, fusion, laser chemistry, biomedical research and engineering, communication optics, and microelectronics.

In these and a broad range of other fields, U.S. science is regarded as equal to or more advanced than any in the world.

In my statement for the record I have indicated a number of facts to substantiate this, but I will point to the incontrovertible evidence of the awarding of Nobel Prizes.

In the last 10 years, American scientists have won or shared nine prizes in chemistry compared to six for all other countries.

In physics, it is 19 U.S. awards to 9 foreign. In physiology or medicine, there were 20 U.S. awards to 8 for foreign scientists; and in economics the count was 9 to 5 in favor of the United States.

The total for the past decade; 57 Nobel Prizes for U.S. scientists compared to 28 abroad, more than double the number for scientists from all other countries combined.

First, let me emphasize again that this administration views basic research as a vital investment with a good return and believes that, as a contribution to overall national security and economic strength, we must maintain health across the spectrum of science, striving for excellence and eminence in all these fields.

However, as I have stated before, there are a number of good reasons why we cannot expect to be preeminent in all scientific fields, nor is it necessarily desirable. The idea that we can't be first across the spectrum of science and technology is not simply a function of our currrent economic situation.

Rather, it is a recognition of changes that have taken place since World War II and the realities of today's competitive world.

This recognition leads to the conclusion that, in science and technology, as in all endeavors, available resources must be identified, comparative advantages assessed, tough choices made, and priorities established, before resources are allocated.

Perennial issues for policymakers—including science policymakers—are how big the budget pie should be and how it should be divided.

I am convinced that if we are to make the most productive use of our scientific resources, we must ask about the best apportionment of research support between the public and private sectors and also about the apportionment among scientific fields and activities.

My perception is that the Federal Government has not always done as good a job as it could and should in making these decisions.

Difficult decisions have been postponed based on the assumption of future growth in the size of the Federal R. & D. budget.

We must now face up to the difficult choices because we know Federal expenditures for science cannot and will not continue to grow in the way they have in the previous three decades.

I believe the discipline of making such hard choices will ultimately benefit science, just as the occasional pruning of a tree can promote, rather than retard, its health.

While this is not a popular notion, budget stringencies force us to think more deeply about how and why we make choices and whether we are in fact using our resources to best advantage.

I recently commented to a fellow scientist who also had been engulfed in the management of science that my own experience leads me to believe that the best overall quality of research may not occur in times of accelerating support but in times of moderate restraint that force qualitative decisions.

After a moment's thought, he reluctantly concurred pointing out that an environment of accelerating support is, however, much more fun.

Reductions in support of a research area do not necessarily lead to a proportional reduction in research output; by exercising discrimination within a discipline, the best and most productive research can continue to be supported.

With this approach, the serendipitous nature of scientific discovery is not denied. A selective emphasis and deemphasis, taking into account past productivity, present vitality, and future promise, is simply good management of public funds.

Besides exercising discrimination in the support of research areas, we must also insure that our research activities are properly capitalized. Even if it means reducing the number of participants in some areas, we cannot continue to assume that equipment and facility needs can be deferred to a better, future budget climate.

The scientific and technological community must learn to participate in this assessment by playing a more forceful and critical role. Through advisory groups, peer review, testimony before the Congress, and other mechanisms, scientists and engineers must exercise the same discrimination that is required in the daily execution of their research.

To those who may still hope for constantly growing budgets across the board, let me say this—that time has passed and we need the scientific community's best and most thoughtful judgment and advice to maintain the health of our science and technology base.

To those who object to such undertakings, and to all my scientific colleagues, I must say that if scientists do not make such choices, others will, but with less acuity.

My views on how we should approach the task of selecting high-quality science have not been a secret. They can be summarized in one word—discrimination. By this I mean application of specific criteria to discriminating between scientific areas that are most promising and those that are less promising through the criterion of excellence and pertinence.

Excellence should be the basis by which one judges the quality of science—the excellence of investigators, the excellence of the field.

In scientific endeavors we should, above all, advocate an unabashed meritocracy.

We must be sure that there is an open door for all to achieve the merit and excellence needed for the best science, and then support the individuals, groups, and institutions who succeed in walking through that door.

For applied research where we have a specific objective in mind, a second criterion must be added, that of pertinence.

While both these criteria involve value judgments and thus the possibility of error, the criteria can be reliably applied at their extremes, thus leading us to emphasize the most promising avenues and to deemphasize those judged to be less promising.

Both excellence and pertinence imply attention to results: What gives us the most return for the dollars spent.

There have been moments since I came to Washington when I worried about the tendency to get caught up in percents of budgets and percent increases in budgets while forgetting that we are interested in results—past, present, and future.

These principles relate to support of science by anyone—public or private, Government or industry, individual or institution.

From the perspective of my office, and of the Congress we must also discuss principles for the division of public and private sector roles and relationships.

Many of the principles for public versus private sector roles are not new. In general, the private sector will not support an adequate level of research because of the inability of a firm to capture many of the benefits, and because of uncertainty, risk, and the need for large-scale, long-term investments.

Private institutions also skew their investments away from basic or long-term research toward applied and short-term research and development, especially in a business environment characterized by a perception of capricious regulation and continuing high inflation rates.

While basic research should be supported by the private sector wherever possible, Government has a key, necessary role in assuring that the support of fundamental research is adequate. Decisions become more complex, however, as we try to decide on what constitutes an adequate level of support.

Before deciding that Federal support or any area is appropriate, we want to insure that the value of the benefits we expect the Nation to derive justifies the cost to the Federal taxpayers. These are not easy judgments to make. Because of this difficulty many have proposed tying support for basic research to some other factor such as GNP, or assuring that there is some specified percent growth each year. I do not believe such an approach is wise, because it does not relate to the quality of the basic research itself. While decisionmaking may not be easy we should not derogate from our responsibility by adopting rules of thumb that tie the support of basic research to some rigid external factor.

With the difficulties of making such judgments in mind, let me suggest some guidelines.

First, because of the nature of basic research and the inherent uncertainty of its application, wide-ranging support across fields and subfields of science should be maintained, thus providing the country with a capability to take advantage of important breakthroughs quickly and to respond to changing needs.

Second, research supported by mission agencies should generally encompass both basic and applied research in disciplines appropriate to the execution of the mission.

Third, Government support of basic research, to the extent such research is carried out in educational institutions, influences our ability to meet our future scientific and technological manpower requirements. Thus, a manpower requirements and research support policy are interdependent and should be coordinated. Increasing participation by the private sector in this process, stimulated by tax incentives for academic research support, will strengthen this link.

Finally, there is less justification for a Federal Government role in applied research and development, except in areas of dominant Federal responsibility such as defense, space, or particular aspects of the regulated nuclear industry. There are also areas of shared responsibility such as health, education, and agriculture, where the broad societal benefits justify some Federal involvement.

While this principle may not sound new to many of you, I think you will find it more stringently adhered to by this administration than has been true in the past.

Let me now turn to some specific issues that are of concern to this administration and to the Congress.

Mr. Chairman, in the statement I am submitting for the record you will find a discussion of issues I consider important such as those involving defense science and engineering education, international cooperation in science, facilities and instrumentation and new institutional demands, including those related to the role of our Federal laboratories.

These are significant science policy issues we have been concerned with and deserving of your consideration.

Mr. Chairman, I have tried to lay out for this committee the philosophy guiding the administration's science policy.

I would like to emphasize that we perceive R. & D. as a means to achieve necessary national objectives. For that reason, I have talked at length today about the administration's efforts to stimulate a strong economy and to provide appropriate incentives for private sector expansion.

I also stress the need for discrimination in science and the role of the scientific community in the formation of science policy. I believe it is vitally important for the community to take a realistic view of the current economic situation and to recognize that the growth that science and technology have enjoyed for so many years cannot continue.

This is certainly no tragedy and is not likely to do harm to the current health of American citizens, but the community must accept its responsibility for considering priorities within a constrained budget and must be willing to identify areas for both increased as well as decreased support.

While this may not be a pleasant process it is hardly unusual. We do it as individuals and we do it as a Nation. If the scientific community can accept those ground rules, it will be in a strong position to share with the Federal Government the responsibility for allocation of recourses.

Finally, I certainly must acknowledge the key role of the Congress as a partner in this policy enterprise. This committee in particular has demonstrated thoughtfulness and leadership over many years as the Nation's science and technology needs and objectives have changed.

I look forward to continued productive cooperation with you during these important times.

Mr. Chairman, I would be happy to respond to questions at this time.

[The prepared statement of Dr. Keyworth follows:]

STATEMENT OF DR. GEORGE A. KEYWORTH, II
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

December 10, 1981

I am both pleased and honored to be here today. Pleased to have an opportunity to discuss the Reagan Administration's science policy with you, and honored to appear before this Committee with three of my distinguished predecessors.

In its stewardship of Federal support of science and technology, this Committee has had a significant impact on the course of our scientific development. And Frank Press, Guy Stever, and Ed David have each played important roles -- not only as science advisors, but throughout their careers.

ECONOMIC CONTEXT

Let me begin by making a point that may appear obvious -- science policy is not made in a vacuum. It is an exercise in priority-setting and decision-making that must be carried out in the context of other national policies such as those concerning national security, international relations, energy, social services, and the economy. For example, science policy, made without considering economic policy, is irrelevant. This is especially true in the present Administration, where the President's economic recovery program is reversing many policies of long standing.

This country has been plagued for years by an unacceptable level of inflation, high interest rates and a runaway Federal budget. Complex and often unnecessary regulations, as well as inadequate incentives to encourage investment and growth in the private sector, have reduced our productivity and international competitiveness. All of these problems are interrelated, of course, and can be overcome only by a coordinated effort.

Though reducing Federal spending has received the most attention, other aspects of the President's economic recovery program have important implications for science and technology.

--In tax policy, it has been estimated that incentives under the Economic Recovery Tax Act and other Administration actions will stimulate an additional $3 billion in corporate R&D spending over the next five years. Most of this is expected to go for applied research and development.

--In regulatory policy, unnecessary barriers to innovation are being removed. As the burden of government regulations is reduced, corporations will not find it necessary to conduct broad "defensive R&D" --aimed at regulatory compliance--and will be able to use these funds for more productive channels of research.

--In fiscal policy, Federal R&D has been strongly influenced by the stringencies of our current economic conditions. There are priorities and limits, and R&D--for all its recognized worth--must contend and compete. Considering the magnitude of the overall budget cuts, however, I believe that most R&D, especially the research area, has fared quite well.

However, we cannot realistically expect to accelerate spending for R&D in a period of fiscal austerity. Support of science and technology--especially basic research--is a long-term investment that represents an essential element in the foundation of a healthy economy. To finance investments in science, both taxpayers and corporate executives must feel sufficiently secure economically to invest in the future. We need a strong economy that encourages risk-taking and can afford appropriate funding of science by both government and the private sector. By helping the President achieve his economic goals, we best address the cause of science and technology.

Within the context of today's national interests and economic policies, what should be the role of the Federal Government in science and technology? What should be the framework and guiding philosophy of our national science and technology policy?

I believe that today's Federal role in science and technology must be be different from that which has prevailed since World War II. What's more, I believe that a changing world as well as changing national goals call for changes in science policy. Certainly, a science policy for the 1980's cannot be and should not be one based simply on growth for growth's sake. Even in a period of affluence and sustained economic growth, throwing money at problems has not proven to be an effective strategy. In fact, it has often been responsible for furthering mediocrity rather than stimulating excellence. But, particularly in these times, we must sharpen our focus and make a concerted effort to allocate our resources in ways that support the most superior, promising and relevant efforts. I am proposing a Federal role in R&D which is appropriate to the 1980s--appropriate to a national mood which calls for increased vigor and acceptance of responsibility by individuals and organizations in the private sector and decreased involvement by the Federal government in many of our affairs. This is the direction in which we are moving, and I will touch on it in more detail later in my statement.

SCIENCE CONTEXT

The Reagan Administration places great value on our country's scientific and technological strength. Supporting science is a necessity for all great nations, and certainly for the United States. Success in achieving virtually all of our national goals for the 1980's--more vigorous economic growth, enhanced national security, a stronger competitive position in world markets, better health and quality of life for all our people--will depend in large part on knowledge and technological developments which can come only from scientific research.

Science is a critical factor in determining our ability and readiness to meet the problems of the unforeseeable future. No one can tell at this time what all the problems of our society will be. But we can be sure that many of them will be inextricably tied to science, and that our future problem-solving capability will depend on the depth and breadth of our scientific knowledge, particularly upon the type of breakthrough that comes from basic research.

I am firmly convinced that the condition of U.S. science is generally healthy. That health is reflected in the excellent and exciting research taking place in many diverse fields, such as high energy physics, agricultural sciences, astronomy, geophysics, fusion, laser chemistry, biomedical research and engineering, communication optics, and microelectronics. In these and a broad range of other fields, U.S. science is regarded as equal to or more advanced than any in the world. Consider the following:

--The United States spends more money on research and development than any other country in the world and has more scientists and engineers engaged in those activities than any other free world nation.

--The ratio of research and development to gross national product in the United States compares favorably to that of other major industrialized countries. In 1978, for example, that ratio in the United States was 2.23 percent compared to 1.93 percent for Japan and 2.37 percent for West Germany. The ratio in the United States is rising and we expect will have reached 2.37 percent in 1981.

--The United States remains strongly competitive in the area of R&D intensive products. They are an increasing proportion of U.S. exports and contribute positively to the U.S. international trade balance. The trade surplus which the U.S. has enjoyed in R&D-intensive products has grown from $6.7 billion in 1962 to $39.3 billion in 1979. Scientific research has contributed heavily to the development of such products.

--The award of Nobel Prizes provides another measure of the health of U.S. science. In the last 10 years, American scientists have won or shared 9 prizes in chemistry compared to 6 for all other countries. In physics, it is 19 U.S. awards to 9 foreign. In physiology or medicine, there were 20 U.S. awards to 8 for foreign scientists; and in economics the count was 9 to 5 in favor of the U.S. The total for the past decade: 57 Nobel Prizes for U.S. scientists compared to 28 abroad, more than double the number for scientists from all other countries combined.

Further, we expect the base of support for science to broaden. Industry is already a key performer of scientific research. It accounts for nearly half of the total U.S. R&D expenditures and is the most dynamic element in our overall R&D effort with almost a doubling of industrially supported R&D over the past five years. A new 25 percent tax credit on incremental R&D expenditures by industry is expected to encourage the trend toward even greater industrial expenditures in R&D.

Notwithstanding the general health of U.S. science, some real concerns must be addressed. All of us here are uncomfortably familiar with them, so I will simply cite briefly several of the more pressing ones:

--Research related to many areas of national defense must be enhanced if we are to ensure our military strength and readiness.

--The declining state of elementary and secondary education in mathematics and science is precluding careers in science and engineering for many good students, threatening the future supply of people needed for these disciplines.

--The increasing sophistication and cost of instrumentation has placed our universities in a critical position both in teaching and conducting research.

--Changing population age distributions affecting both university students and faculty endanger a principal mechanism that universities have for maintaining their health as performers of research, the constant infusion of bright, young talent with fresh ideas and perspectives.

I will return to these issues later. First, let me emphasize again that this Administration views basic research as a vital investment with a good return and believes that, as a contribution to overall national security and economic strength, we must maintain health across the spectrum of science, striving for excellence in all these fields.

However, as I have stated before, there are a number of good reasons why we cannot expect to be preeminent in all scientific fields, nor is it necessarily desirable. The idea that we can't be first across the spectrum of science and technology is not simply a function of our current economic situation. The fact is that immediately after World War II this country was alone in developing and pursuing technology. Since then the rest of the world has been catching up--with much help from us. Japan and Western Europe have achieved technological competitiveness, if not parity. This is healthy for the world and for its stability. We should look on this as a major success of our social values and recognize that economically strong and competitive democracies in Japan and Western Europe favor our national interests. However, it follows that, because of the diversity inherent in industrial democracies, there are certain areas of science and technology that are more pertinent to other countries than to us. It is in these areas that others will attempt to be world leaders. But, there are areas where the U.S. is a leader and must remain so. This realization does not represent either a defeatist attitude nor a lack of confidence in American scientists and engineers. Rather, it is a recognition of the realities of today's competitive world. This recognition leads to the conclusion that, in science and technology, as in all endeavors, available resources must be identified, comparative advantages assessed, tough choices made, and priorities established, before resources are allocated.

RESOURCE ALLOCATION IN SCIENCE

Perennial issues for policymakers--including science policymakers--are how big the budget pie should be and how it should be divided.

I am convinced that if we are to make the most productive use of our scientific resources, we must ask about the best apportionment of research support between the public and private sectors and also about the apportionment among scientific fields and activities. My perception is that the Federal Government has not always done as good a job as it could and should in making these decisions. Difficult decisions have been postponed based on the assumption of future growth in the size of the Federal R&D budget. We must now face up to the difficult choices because we know Federal expenditures for science cannot and will not continue to grow in the way they have in the previous three decades.

In this time of economic restraint we need to make tough decisions --tougher than were necessary during eras of rapid growth. There is an inevitable tendency when budgets are increasing to add resources to the best research areas, but not to take money away from less productive research areas, even if they have passed the days of their most important and exciting work. We can no longer afford that luxury. Similarly, in tight budget times, there is a tendency to avoid tough decisions by applying cuts uniformly across all fields. We can no longer allow ourselves this easy way out of hard choices.

I believe the discipline of making such hard choices will ultimately benefit science, just as the occasional pruning of a tree can promote, rather than retard, its health. While this is not a popular notion, budget stringencies force us to think more deeply about how and why we make choices and whether we are in fact using our resources to best advantage. I recently commented to a fellow scientist who also had been engulfed in the management of science that my own experience leads me to believe that the best overall quality of research may not occur in times of accelerating support but in times of moderate restraint that force qualitative decisions. After a moment's thought, he reluctantly concurred pointing out that an environment of accelerating support is, however, much more fun.

Reductions in support of a research area do not necessarily lead to a proportional reduction in research output; by exercising discrimination within a discipline, the best and most productive research can continue to be supported. With this approach, the serendipitous nature of scientific discovery is not denied. A selective emphasis and deemphasis, taking into account past productivity, present vitality, and future promise, is simply good management of public funds. Besides exercising discrimination in the support of research areas, we must also ensure that our research activities are properly capitalized. Even if it means reducing the number of participants in some areas, we cannot continue to assume that equipment and facility needs can be deferred to a better, future budget climate.

The scientific and technological community must learn to participate in this assessment by playing a more forceful and critical role. Through advisory groups, peer review, testimony before the Congress, and other mechanisms, scientists and engineers must exercise the same discrimination that is required in the daily execution of their research. I do not believe that there are inherent scientific difficulties for experts in a given discipline to identify areas to deemphasize as well as those meriting new emphasis. Rather, the real difficulties arise from the psychological and sociological aspects of the issue. It is necessarily more difficult when the assessment spans several fields and parochialism inevitably interferes. Yet, I believe judgmental decisions can be made more effectively than we have in the past.

To those who may still hope for constantly growing budgets across the board, let me say this -- that time has passed and we need the scientific community's best and most thoughtful judgment and advice to maintain the health of our science and technology base. To those who object to such undertakings, and to all my scientific colleagues, I must say that if scientists do not make such choices, others will, but with less acuity.

PRINCIPLES FOR ALLOCATION IN SCIENCE

My views on how we should approach the task of selecting high quality science have not been a secret. They can be summarized in one word--discrimination. By this I mean application of specific criteria to discriminating between scientific areas that are most promising and those that are less promising. The first criterion must be excellence. Excellence should be the basis by which one judges the quality of science --the excellence of investigators, the excellence of the field. In scientific endeavors we should, above all, advocate an unabashed meritocracy. We must be sure that there is an open door for all to achieve the merit and excellence needed for the best science, and then support the individuals, groups, and institutions who succeed in walking through that door.

For applied research where we have a specific objective in mind, a second criterion must be added, that of pertinence. While both these criteria involve value judgments and thus the possibility of error, the criteria can be reliably applied at their extremes, thus leading us to emphasize the most promising avenues and to deemphasize those judged to be less promising.

Both excellence and pertinence imply attention to results: What gives us the most return for the dollars spent? There have been moments since

I came to Washington when I worried about the tendency to get caught up in percents of budgets and percent increases in budgets while forgetting that we are interested in results -- past, present and future.

These principles relate to support of science by anyone--public or private, government or industry, individual or institution. From the perspective of my Office, and of the Congress, we must also discuss principles for the division of public and private sector roles and relationships.

Many of the principles for public versus private sector roles are not new. In general, the private sector will not support an adequate level of research because of the inability of a firm to capture many of the benefits, and because of uncertainty, risk, and the need for large-scale, long-term investments. Private institutions also skew their investments away from basic or long-term research toward applied and short-term research and development, especially in a business environment characterized by a perception of capricious regulation and continuing high inflation rates.

Arguments for a government role in civilian R&D apply most strongly to basic research. While some basic research is supported by the private sector, the results of basic research do not generally show up directly as new products or production processes, but as information and knowledge that are easily and widely available to everyone. Thus, there is less incentive for firms to support basic research. Basic research warrants government support because it is an investment in the future--in a better quality of life, better security, a better economy, and simply better understanding. In addition to its general societal benefit, basic research is essential to the conduct of many activities, such as defense and space, for which the Federal Government has responsibility. It should thus be a component part of the research budgets of all government agencies whose missions depend upon a strong scientific and technological base.

While basic research should be supported by the private sector wherever possible, government has a key, necessary role in assuring that the support of fundamental research is adequate. Decisions become more complex, however, as we try to decide on what constitutes an adequate level of support.

Before deciding that Federal support of any area is appropriate, we want to ensure that the value of the benefits we expect the nation to derive justify the cost to the Federal taxpayers. These are not easy judgments to make. Because of this difficulty many have proposed tying support for basic research to some other factor such as GNP, or assuring that there is some specified percent growth each year. I do not believe such an approach is wise, because it does not relate to the quality of the basic research itself. While decision-making may not be easy, we should not derogate from our responsibility by adopting rules of thumb that tie the support of basic research to some rigid external factor.

With the difficulties of making such judgments in mind, let me suggest some guidelines. First, because of the nature of basic research and the inherent uncertainty of its application, wide-ranging support across fields and subfields of science should be maintained, thus providing the country with a capability to take advantage of important breakthroughs quickly and to respond to changing needs.

Second, research supported by mission agencies should generally encompass both basic and applied research in disciplines appropriate to the execution of the mission.

Third, government support of basic research, to the extent such research is carried out in educational institutions, influences our ability to meet our future scientific and technological manpower requirements. Thus manpower requirements and research support policy are interdependent and should be coordinated. Increasing participation by the private sector in this process, stimulated by tax incentives for academic research support, will strengthen this link.

Finally, there is less justification for a Federal Government role in applied research and development, except in areas of dominant Federal responsibility such as defense, space, or particular aspects of the regulated nuclear industry. There are also areas of shared responsibility such as health, education, and agriculture, where the broad societal benefits justify some Federal involvement. The case for government support of development is weak, except for areas where government is the sole or dominant buyer.

We should not subsidize technological development and demonstration that is within the capability or responsibility of the private sector to support. While this principle may not sound new to many of you, I think you will find it more stringently adhered to by this Administration than has been true in the past.

Let me now turn to some specific issues that are of concern to this Administration and to the Congress--defense, science and engineering education, innovation, international cooperation in science, facilities and instrumentation, and institutions of science.

SPECIFIC ISSUES

Defense

We have made it clear in earlier statements that the Administration considers two areas--industrial rejuvenation and national defense--to be critically dependent on near-term advances in science and technology. Those priorities are evident in our economic policies and in our R&D budget proposals. We expect industrial progress to be fueled primarily by the more favorable economic climate for investment provided in The Economic Recovery Tax Act, and we plan to ensure our defense needs by direct government R&D funding. Specifically, we have proposed to increase FY 82 Department of Defense R&D by 21 percent over 1981. Within that funding, we also plan an increase of 15 percent in basic research funding within DoD.

I wish to make it clear, however, that these are long overdue increases and they represent a carefully considered evaluation of R&D needs and opportunities in defense areas. In recent years we have deferred attention to a number of pressing defense needs--both technological and operational--and we must now make some substantial commitments to support restoration of an adequate defense R&D base. But precisely because defense needs are so broad, we still face hard choices in what needs we can reasonably meet.

Basically, we look to science and technology to provide us with technological superiority in defense. As a free nation, we cannot match our potential adversaries in terms of manpower or deployment of materiel. Our ability to develop a "stealth" technology to protect aircraft is an example of a way to substitute superior technology for sheer numbers. To pursue this objective we must support programs and institutions that seek, nurture, and capitalize on the kind of new knowledge that supports development of new technologies. We will continue to evaluate our overall science and technology program --both civilian and military--to make sure that the flow of both knowledge and personnel is adequate to meet future defense needs.

Science and Engineering Education

Certainly one of the critical parts of the science and technology infrastructure is the nation's education system. We are, today, experiencing shortages of qualified personnel in several specific areas--notably computer science and some fields of engineering--and are told that these shortages may extend to additional technical fields in coming years. These shortages result primarily from the good health and vitality of some very productive industries, which are growing rapidly. Unfortunately, the accompanying high demand for

for the best young talent is having a deleterious effect on our nation's universities. Not only are the universities finding it increasingly difficult to recruit and retain faculty, but they also find it increasingly difficult to attract graduate students, because industry is quite willing to hire BS or MS engineers and computer scientists at high salaries.

But, although this situation has serious national implications, it is primarily one of a marketplace working as it should, and does not require a massive Federal response. In fact, in the very few years that this situation has been developing, we have seen substantial private sector concern and response. Industry knows all too well that it is critically dependent on a healthy university system, both for new knowledge and new talent. Leaders in engineering fields and high-technology industries are actively seeking new mechanisms--ranging from increased private sector financial support of education to stimulation of new resources from State governments. As I pointed out in my statement to this Committee on October 7, this is a problem that must, and can be worked out by those who supply scientific and engineering manpower and those who utilize it. If there are questions of the quality and future availability of technical manpower -- and there are such questions -- it clearly is in the best interests of the "consumer" to take the necessary actions to ensure that its needs are met. And in this case, the needs of industry, the demand on the academic community to meet those needs in a way that promotes continued academic excellence, and the needs of the Nation for technological growth are generally congruent.

Underlying current problems with the quantity and quality of trained scientific and engineering manpower is the weakness, overall, in our country's elementary and secondary school preparation in mathematics and science. Since 1970 there has been a nationwide trend toward reduction of high school graduation requirements in mathematics and science. In response, colleges have reduced their math and science requirements for admission. By the age of 15 or 16, most students have made a decision that effectively cuts them off from future careers in science and engineering--which just happen to represent the fastest growing career opportunities.

Contrast this practice with that of other industrialized countries. In Japan nearly all college-bound students take three science and four math courses during high school. West Germany is similar, and emphasis in the Soviet Union upon science and technology in elementary and secondary schools is even greater.

While I don't necessarily endorse the philosophies that guide those other systems, I am impressed with their pragmatic commitments to science education. And it seems obvious to me that this is an area in which our system is deficient. The causes are not at all clear. But, I suspect that the most important determining factor is the public attitude toward education and toward science and technology.

Despite the Administration's real concerns in this area, improvement in this unfortunate situation is the responsibility of the schools themselves and of the communities that run them. It is up to the state and local governments to decide what kinds of specific resources should be provided for science and mathematics education in their schools--and to provide them. This diversified responsibility should also encourage the local assistance and participation by industry and professional groups in developing adequate programs in science and mathematics education.

INDUSTRIAL INNOVATION

There is increasing evidence of decline in innovation in industry paralleling the decline in the health of the economy and increasing Federal regulation. Long-term investment and risk-taking have suffered as the result of economic uncertainty, and research and development have focused on incremental changes in existing products and on meeting regulatory requirements as the result of increasing corporate conservatism and Federal regulatory activity.

The economic vitality and international competitiveness of this Nation depend on a strong, innovative industrial sector. It is the policy of this Administration to strengthen the industrial sector and to stimulate its innovativeness, not through direct Federal subsidies and intervention in corporate decision-making, but through the provision of incentives and elimination of disincentives. Accordingly, The Economic Recovery Tax Act signed by President Reagan earlier this year, contains R&D tax credits, accelerated depreciation schedules and other incentives designed to stimulate increased corporate investment in research, development, and innovation. In addition, we are working with this Congressional Committee and others to fashion patent legislation which assigns to private sector organizations the rights to patents developed under Federal R&D funding. Over the next several months, we will be directing increased attention to these and other incentives designed to increase innovation.

Similarly, I am increasing my involvement in Administration efforts to lighten the Federal regulatory burden on the private sector. We feel that an effective approach to making Federal regulations more rational is to strengthen the scientific basis for regulatory decision-making. Recently I was appointed to the President's Task Force on Regulatory Relief, chaired by the Vice President, and asked to chair a regulatory work group on science and technology including the heads of the five major environmental, health, and safety regulatory agencies. We intend to use these mechanisms and others to improve, through science, the rational bases for establishing regulatory priorities.

International Cooperation in Science

Let me now turn to another area--international cooperation in science. Scientists have traditionally led the way in searching out those around the world whose work was allied to theirs. Certainly the United States benefitted tremendously before World War II from the interaction of its scientists with European scientists, and we benefit today from the healthy competition among scientists of all nations.

Particularly in areas of basic research, international cooperation today offers us some welcome opportunities to share expensive frontier research that otherwise would be impractical to pursue. We should embrace the opportunities to join with other nations in sharing the high costs of modern facilities and instrumentation. Just as American scientists travel elsewhere to do research, we have long welcomed foreign astronomers to our observatories, foreign oceanographers to our ships, and foreign physicists to our accelerators, and we will soon be carrying foreign satellites in our Space Shuttle. We are all richer for the experience.

Our general policy with regard to investment in these and other, more elaborate, joint projects is that we will give priority to those projects that best serve our national needs.

Facilities and Instrumentation

I mentioned earlier the need for the scientific community itself to share responsibility for establishing research priorities in the many fields of science and engineering. I think it likely that the various communities will be called on to make similar decisions about new facilities. Across many different disciplines in universities, equipment and instrumentation for both research and instruction are outdated and obsolete. I am myself convinced of the serious needs for modern equipment in our research universities.

But, I am not convinced that the solution lies with the Federal government alone. I believe that the communities themselves, working with their supporting agencies, must decide which of their needs are most important and how best those needs can be met. For example, a university may be forced to decide whether its equipment needs are important enough to justify an offsetting reduction in some other category of support--or possibly in the number of projects supported? Such decisions are not easy, but scientists should participate in such judgments. It seems clear that a more sustainable ratio of capital to operating funds in our research support must be achieved. For this reason, the Economic Recovery Tax Act contains tax incentives for industrial equipment contributions to academic institutions. It is intended that these incentives will help to increase the role of the private sector in maintaining and upgrading the quality of university research equipment and facilities.

Institutions of Science

I am concerned, as I know you are, about how well the various institutions that we rely on for research and development are prepared for the future. In particular, universities and federal laboratories, important national resources and key to our overall science and technology base, are faced with re-evaluating their roles.

The universities' immediate problems are financial. Because of large commitments to fixed costs of faculty salaries and maintenance of facilities, many are poorly positioned to adjust to current and projected decreases in student populations. That, plus the ever-present problems of shifts in course enrollment -- such as the current high demand for courses in computer science and engineering--may force some structural changes in higher education. For example, universities, which have traditionally responded to demand and paid higher salaries to medical and law faculty than to other faculty, may be forced to further perturb the concept of equality among professors by raising engineering faculty salaries to attract new engineering professors and to keep those they have from leaving.

Some institutions may also find that the tenure system, coupled with low turnover in most faculty positions, commits them to maintain a large, aging faculty unsuited to today's -- or tomorrow's -- instructional needs. In the absence of growth in faculty size, hiring of new, young faculty members becomes nearly impossible. This can have serious impacts on the integrity of the institution itself, and we may see some attempts to modify the tenure system to restore some flexibility to the schools.

The Federal Government is unlikely to intervene in this process, even though it has a stake in the continued health of university research and associated education. Instead, I see the government's primary role as a supporter of needed research. The universities, along with the science and engineering communities, must assume responsibility for creating a campus environment in which the best researchers want to work and teach, or take the chance that a deteriorating quality of life on campus may drive the researcher elsewhere. The current tug-of-war between industry and universities for molecular biologists is a striking indication of the pressures that can develop.

The role of the Federal laboratories is different again, because they are creatures of the government. But many of them are now more than 30 years old, their original missions in some cases long ago accomplished or outdated. A large amount of Federal R&D funds goes to these labs. Can we honestly say that all of it is well-spent according to the criteria of excellence and pertinence? I intend to concentrate on this issue during the coming year as we examine the role of these institutions, look at their missions, and evaluate the returns on our investments. One thing we should be thinking about, however, is how changes in the Federal labs could complement changes in universities. Perhaps the labs may be able to augment the research opportunities at universities through broader use of their extensive facilities. The labs, like the universities, can play an important role in preserving and enhancing our national capability to produce new science and technology and to train new scientists and engineers. However, one caveat: the Federal labs should not slip into a situation where they are competing with private sector research. That means they must have clearly defined missions of importance to the country.

CONCLUSION

Mr. Chairman, I have tried to lay out for this Committee both the philosophy guiding the Administration's science policy as well as our positions on some specific issues. I would like to emphasize that we perceive R&D as a means to achieve necessary national objectives. For that reason I have talked at length today about the Administration's efforts to stimulate a strong economy and provide appropriate incentives for private sector expansion. And, I have discussed the appropriate role for government in science -- where, as in defense or basic research, government has a clear responsibility, and where, as in commercially oriented development, it does not. I want also to make the point that we believe this division of responsibility, coupled with the variety of incentives being provided to the private sector, will encourage and stimulate economically and socially beneficial innovations on a broad scale.

I have also stressed the need for discrimination in science and the role of the scientific community in the formation of science policy. I believe it is vitally important for the community to take a realistic view of the current economic situation and to recognize that the growth that science and technology have enjoyed for so many years cannot continue. This is certainly no tragedy and is not likely to do harm to the current health of American science. But the community must accept its responsibility for considering priorities within a constrained budget and must be willing to identify areas for both increased and decreased support. While this may not be a pleasant process, it is hardly unusual; we do it as individuals and we do it as a nation. If the scientific community can accept those ground rules, it will be in a strong position to share with the Federal Government the responsibility for allocation of resources.

Finally, I certainly must acknowledge the key role of the Congress as a partner in this policy enterprise. This Committee in particular has demonstrated thoughtfulness and leadership over many years as the Nation's science and technology needs and objectives have changed. I look forward to productive cooperation with you during these important times.

Mr. Chairman, I would be happy to respond to questions at this time.

Mr. **Fuqua**. Thank you very much, Dr. Keyworth. You have mentioned the Government responsibility in basic research and so forth.

Has the Government done a very good job in managing its basic research activities over the last number of years?

Dr. **Keyworth**. I think the Government has done a reasonable job, perhaps even a good job. The point that I am trying to make is that I believe the Government can do a considerably better and more responsible job in the future.

Mr. **Fuqua**. In the fiscal year 1982 and 1983 cuts that are under discussion and coming up now, do you see a series of years, say 1984 and 1985 as well, as requiring further cuts in the R. & D. budget before a period of stability is reached or will we reach a period of stability prior to that time?

Dr. **Keyworth**. Mr. Chairman, I worry about this as I know you do, because periods of fiscal constraint can be beneficial over relatively short periods, in my opinion.

I will simply point out that to separate growth in the Federal support of science and technology from growth in the Nation's economy is in my opinion not realistic, but I do have serious concern about maintaining the health of the science and technology base of this country over extended periods of intense fiscal constraint, and I think it points again to the simple fact that if the country's economy deteriorates over a long period of time, our science and technology will necessarily follow.

Mr. **Fuqua**. In the field of science and engineering education, which I think is very critical to our science and technology structure that we have in the country, you suggest in your statement that the responsibility rests with local schools and communities.

You do not feel that there is a strong Federal role in providing leadership in these areas of manpower training?

Dr. **Keyworth**. I think the Federal Government has a clear and permanent role in the leadership of American education. It is certainly maximum at the college and graduate level because we the Federal Government are the principal supporters of the research that supports this training.

On the secondary school level, for example, and lower, high schools and primary schools, I believe very strongly that the Federal Government also has a role, but that the primary role rests in the hands of the State and local governments.

Dr. **Fuqua**. You mentioned that we have all been very proud of the number of Nobel Prize winners that we have had in science and medicine and all the scientific fields, and you cited that in your testimony.

That came from investments we made in basic research in years past. Do you think the course that we are following now would result in a deterioration of the quality of scientific work and, say, the number of awards?

I know we have no lock on the Nobel Prize winners, but we have historically led the world in the number that have received that prestigious award. Do you think that 10 years from now, 20 years from now, that we will see an erosion of that support?

Dr. **Keyworth**. Mr. Chairman, I believe fervently that a concentration on quality can improve the overall strength of the American basic research activity.

However, we must be realistic in observing the increased activity in other parts of the world. For example, Japan to this day has a very small activity in basic research.

I personally discussed with the Prime Minister of Japan, and the Minister responsibile for science and technology their present interest and emerging interest in trying to build a basic research capability in Japan.

I think necesarily the rest of the free world will expand its activity in this area and, therefore, I expect that the sort of majority position that we have maintained in the past may not be as large.

However, I emphasize that the health and quality of our scientific base I think can continue to flourish and increase with an emphasis upon quality.

Dr. **Fuqua**. Thank you.

Mr. Winn?

Mr. **Winn**. Thank you, Mr. Chairman.

Mr. Chairman, I think I will pass on my questions and give the rest of the committee a chance, and ask that you recognize me at the end.

Mr. **Fuqua**. Mrs. Bouquard?

Mrs. **Bouquard**. Thank you very much, Mr. Chairman.

Dr. Keyworth, what is your view of the science advisor's role in determining the applied research and technology development budgets of the R. & D. agencies?

I am sort of concerned about what your priorities were in having a say in these budgets. For instance, do you intend to appeal the OMB cuts in DOE's nuclear fusion or fossil energy programs and how do you feel about the cuts in NASA's programs?

Dr. **Keyworth**. My role has been a quite clear one. I have served as an adviser to those elements of the White House that have been involved in preparing and discussing the fiscal 1983 cuts in all areas that encompass science and technology.

The specific ones to which you refer, I have been intimately involved with and I will simply apologize for the fact that since we are in the midst of the appeal process, I would rather not comment at this time on my specific stance.

Mrs. **Bouquard**. I notice that our support for fusion R. & D. is dropping in spite of the administration's rhetoric about saving the nuclear option.

The R. & D. is being taken out and we are not having the partnership with industry which has been so important, and I think it is a very vital element of our international trade policy.

Dr. **Keyworth**. I certainly agree with your interest. However, our support of nuclear energy has addressed one principal objective, restoring health to the nuclear industry to an extent that will allow nuclear energy to compete with other energy sources.

I contend that much of the role that the Federal Government has played in the past in support of nuclear energy is tantamount to the role of a dead hand on the activity of private enterprise.

We are trying, in other words, to target our spending in support of nuclear energy as directly as we possibly can, and we have been in very close consultation and partnership with the private sector, utilities, the nuclear industry, et cetera, in trying to assess these directions.

Mrs. BOUQUARD. I held hearings in my subcommittee this week on the issue of electric energy systems and storage, where the administration has told us that there will be zero funding for these programs, that they feel there is no Federal role in developing technology to transmit or store energy.

We know very well that our allies are going to take the ball and run with it and this is another area where we are going to lose out on the balance of payments.

It is true that there are tax incentives for industry to expand, but this only helps for short-term R. & D. But for the long-term R. & D., 20 or 30 years, there is not sufficient incentive or money in the private sector to take the ball on this R. & D. work.

Dr. KEYWORTH. I think the Federal Government and this administration is proposing a very healthy and realistic support of long-term energy R. & D. I think the private sector is carrying an increasingly important role in the support of primarily short and midterm activities.

I think the principal concern and differences between our administration and previous administration's involves this midterm area. We are watching today the actions of private industry in taking new directions and pursuing new directions in energy R. & D., and I will say that I think we are totally encouraged at the actions and directions that we see occurring today.

I think the Federal Government is supporting a very healthy, stable, and adequate long-term basic research capability to support energy R. & D., in summary.

Mrs. BOUQUARD. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mrs. Bouquard.

Mr. Flippo?

Mr. FLIPPO. It is a pleasure to have you here, Dr. Keyworth.

In the Washington Post you were reported to have recommended against the continuation of NASA's planetary program. Is this true?

Dr. KEYWORTH. I would welcome an opportunity to elaborate somewhat on that rather crisp statement attributed to me.

The answer goes back to the word "discrimination" that I used as the center theme in my testimony. We have produced a new era in space science with the new capability of the Space Shuttle.

I offered that as a statement and followed with the statement that planetary research—planetary exploration has dominated the American space science program for more than the last decade.

We desire to support a strong space science program across the three general areas of what I will call space science: Planetary exploration, solar-terrestial science, and astronomy and astrophysics.

Mr. FLIPPO. How do you feel about the Galileo project? Have you supported it to OMB?

Dr. KEYWORTH. I have discussed the Galileo project extensively with OMB. I think it is a good mission. The question of whether we can afford it is under consideration now.

Mr. FLIPPO. Have you specifically supported it to OMB?

Dr. **Keyworth**. I cannot comment on the role that I have taken as an adviser to the administration on a specific budgetary issue under consideration at this time. Excuse me.

Mr. **Flippo**. You talk about the health of U.S. R. & D. and its percentage of GNP. Are you including in your figures R. & D. for the military when you talk about the growth?

Dr. **Keyworth**. Yes.

Mr. **Flippo**. How does the growth of R. & D. as a percentage of GNP compare when you remove R. & D. for the military?

Dr. **Keyworth**. Are you speaking in fiscal year 1982 or 1983?

Mr. **Flippo**. You made the statement in your testimony that R. & D. expenditures over the last several years had compared favorably with other nations and I was just wondering if you were including military R. & D. in your statement on page 5 in the middle, where you note that the ratio of research and development to GNP in the United States compares favorably to that of other industrialized nations.

I am wondering if you include military R. & D. in those figures.

Dr. **Keyworth**. Yes, I do.

Mr. **Flippo**. How would it compare if you removed military R. & D.? I think a reference to Japan should remove military R. & D. Japan has no military R. & D. and I was wondering how well we are doing if you eliminate that?

Dr. **Keyworth**. I have in front of me the new science indicators that addressed total research expenditures, not R. & D. expenditures, which I believe will address the point that you are trying to make.

I see from 1960 to 1981, with a couple of exceptions, a constant increase in constant 1972 dollars.

Mr. **Flippo**. Well, I note on page 16 you say that we need to restore an adequate R. & D. base, and I think your reference there is to military or defense R. & D.

How do you classify military R. & D. or defense R. & D.? Today we are greatly dependent upon civilian nuclear power, but during the efforts of the thirties and forties, nuclear science was closer to military R. & D., wasn't it?

Dr. **Keyworth**. That is a good point. That is why I emphasize that I believe all the mission agencies should support a substantial level of research in those disciplines appropriate to their mission.

The Department of Defense supports, and I believe the fraction will grow in the future, an excellent basic research program. MIT and Cal-Tech were built largely with DOD funds.

Mr. **Flippo**. Mr. Chairman, I would just conclude by saying that I agree with your statement that science policy made without considering economic policy is irrelevant, and I think that economic policy without regard to science policy is also irrelevant.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you.

Mr. Weber?

Mr. **Weber**. Thank you, Mr. Chairman.

I have a couple of areas that I would like to ask Dr. Keyworth about, and I realize some of this is speculative. One area, initiated by Congressman Ritter when he was a member of the committee, is putting risks and hazards into perspective. He has legislation dealing with that subject which this committee is probably going to work on next year.

I wonder if you have looked at that legislation and what your comments might be on putting hazards and risks into perspective and, more specifically, comment on Congressman Ritter's legislation.

Dr. KEYWORTH. I have been appointed to the Task Force on Regulatory Reform, because of the recognition of the importance that scientific bases play in a rational regulatory decisionmaking process, and it is becoming a major activity of myself and my office.

We have been working with Congressman Ritter on his bill. We have been discussing the objectives and I believe that we, with joint effort, are coming up with a bill that the administration can enthusiastically support.

Mr. WEBER. So you expect to be supporting the Ritter bill at some point?

Dr. KEYWORTH. Yes, I do.

Mr. WEBER. The second area I would like to ask about involves one of the trial balloons, or leaks, or whatever you call it, that we have been reading about lately in the area of the National Science Foundation budget.

I supported the budget levels that the administration asked for last time and would like to do so again. However, the committee disagreed with the administration's contention that we should zero out the science and engineering education area.

Now we hear that that again is possibly going to be proposed by OMB or whoever proposes those things.

Can you give me your thinking on science and engineering education, what the Federal Government's role should be in that area? Why do you feel that such a program is a less virtuous pursuit than some of NSF's other activities?

Dr. KEYWORTH. I have been spending a considerable amount of my time on this subject. I wish to point out that this administration perceives the Government's role in science and engineering education as an important one.

However, I spoke of discrimination. The administration posture on the National Science Foundation budget for science and engineering education was one based primarily upon a value judgment, a measure of the excellence of those programs, not of the NSF's role in science and engineering education.

We believe that fellowships are in part a Federal responsibility. I have encouraged the National Science Board to identify future directions that the National Science Foundation can follow in improving our education base, and I was just informed yesterday, in fact by John Slaughter, that they are proposing and trying to develop a program in support of improved secondary school science education.

Mr. WEBER. I appreciate your perspective. I would like to endorse your comments on the graduate fellowships. My State is host to high technology organizations about as much as any. I have talked with people at Honeywell, 3M, and Control Data and they believe that the fellowship is extremely valuable, and if any program in NSF deserves expansion, it should be that one.

One controversy that ranges throughout this committee, whether it involves synfuel plants or Clinch River or any other project is the administration's policy that appears to favor not R. & D. but actual commercial-level projects.

I would like to get your thoughts on that if I could.

Dr. **Keyworth**. I think it is clear that our administration feels that the Federal role in demonstration should be minimal—even approaching zero—except in those areas where the Federal Government is the primary recipient, such as defense, for example.

The exceptions I think that are presently perceived can be attributed to specific considerations such as the nuclear industry.

Mr. **Weber**. I would like my silence to indicate that I am out of time, not that agree with that.

Mr. **Fuqua**. Thank you.

Mr. Gregg?

Mr. **Gregg**. Well, to follow on that question, Doctor, if one accepts that logic, and also the logic which you earlier related that the nuclear industry must be competitive and that your participation in the nuclear industry is to create a competitive climate, I can anticipate that the administration is not going to support the Clinch River reactor in 1983.

Dr. **Keyworth**. I personally support, as does the administration, the Clinch River enthusiastically for a specific reason. The nuclear industry is suffering today from the impediments that have been imposed by the Federal Government over a period of time.

I think that it is a Government responsibility to remove as easily and as quickly as possible some of those burdens that have been imposed upon the industry.

I think the Clinch River, a midsize breeder project, is a technical development project that is an appropriate Federal responsibility.

I personally have never seen it as the dichotomy that it is so often perceived as.

Mr **Gregg**. I guess this isn't the proper time to debate that. As we go into 1983, do you anticipate that rumors we hear now are accurate that research and development in areas such as solar, conservation, fossil fuel, are going to be cut by 50 percent?

Dr. **Keyworth**. I think it is possible the administration will propose specific cuts in these areas where the short-term payoff is greatest, yes.

Mr. **Gregg**. Does your office support that?

Dr. **Keyworth**. Yes.

Mr. **Gregg**. I would just represent from my viewpoint that I was probably one of the administration's strongest supporters on this committee last year, but I don't believe that going back into those areas which have been cut dramatically in the last budget go-around is going to be worthwhile or receive much sympathy, at least from myself. I will leave it at that.

How do you think that we can improve the R. & D. efforts of the general activities of the Department of Energy? What are your thoughts in that area?

Dr. **Keyworth**. By focusing, would be my answer, by trying to focus on those areas where the payoff is greatest, where the technology is not likely to be pursued by the private sector, and I think that is a succinct description of the administration's energy policy and the role that the Department of Energy plays in fulfilling that policy.

Mr. **Gregg**. Thank you very much.

Mr. **Fuqua**. Mr. Skeen?

Mr. **Skeen**. Thank you, Mr. Chairman.

I would like to follow up on that same line of thought because the interim report from the Energy Research Advisory Board on the R. & D. needs of the Department of Energy, states that due to the pressure for near-term technical solutions to energy programs and the rapidly rising costs of operational research facilities, the funding of basic research has been declining and is inadequate to meet the long-term needs of the Nation.

I would like you to expand on that statement.

Dr. **Keyworth**. Thank you, because my office has paid particular attention to the role of the Office of Energy Research in the Department of Energy.

In the first place, some of the best basic research that is conducted in this country is supported by the Office of Energy Research and we have been extremely concerned about the health of the activities in that area.

I think that when the President's budget submission for fiscal 1983 is proposed in January, those who share that concern will be pleased and will see the actions that our administration has taken.

Mr. **Skeen**. We are getting down more to a priority system than we have had in the past, rather than trying the scattergun approach to solving energy problems?

Dr. **Keyworth**. I think you just stated it better than I have.

Mr. **Skeen**. Thank you. I wasn't trying to do that.

Thank you.

Mr. **Fuqua**. Mr. Walgren?

Mr. **Walgren**. I want to welcome Dr. Keyworth to the committee.

Mr. Chairman, if I might, I have an opening statement.

The **Chairman**. Without objection, it will be made a part of the record.

Mr. **Walgren**. Dr. Keyworth, with respect to the National Science Foundation and your expressions of your views on science education and the support thereof, I wanted to ask whether you have been rethinking the role of the Federal Government with respect to science education, particularly through the National Science Foundation?

All the evidence that I see presented to my subcommittee is that there must be a Federal role in this area. The quality of students, particularly thinking now at the secondary level, the quality of students in their initial exposure to science as they come into college and come out of the secondary level is just woefully lacking with respect to the initial training in science that is necessary even if they are to have the option to pursue a scientific career.

And there are people on the boards of college trustees that have made that point again and again.

How can we solve that problem if we don't have some strong goals and programs coming from the Federal level that will help upgrade the secondary level of education in science in this country?

Dr. **Keyworth**. I think the answer is there must be a Federal role. I think there must be a partnership between States and local governments and the Federal Government.

I think that the Federal Government has played an important role in the past and I will point to the curriculums development that the National Science Foundation funded in the sixties, which I think had a substantial benefit.

We are trying to encourage in this case the National Science Foundation to examine that role carefully and to propose a role that they should carry out in context of today's problems. We are concerned.

We are also concerned that the paths we have been pursuing in the last few years are not the paths that we need to pursue to address this critical problem that you describe.

Mr. **Walgren**. As you know, the curriculum development effort has been eliminated. I believe we all should question at all times to try to improve things, but it strikes me that what we hear from the administration so far are voices saying that this program has been ineffective and, therefore, we are eliminating it because of our view of the Federal Government as not being properly involved here.

Is there anything that you can replace or do you have any suggestions what we could replace these programs with for those that you have criticized as ineffective in the past?

Dr. **Keyworth**. I feel presumptuous in responding because I am not an expert in education. I have encouraged the National Science Board to pursue possible initiatives, and we have brought in a large number of educators and professionals to discuss this with us, and we are trying to identify programs that will be most effective in the past. A program with a title is not a program of effectiveness.

Mr. **Walgren**. Well, I certainly would agree with that, but I would really like to underscore the fact that these programs have made some contribution. It would seem to me that if we are losing these people wholesale because they have no decent exposure to the development of science at the secondary level, before we eliminate what little progress we are making on that level we ought to have strong programs to put in their place that would meet the need. Perhaps I could submit something further in writing.

Mr. **Fuqua**. Yes. We may have some questions to submit.

Mr. Dunn, you have got about 1 minute.

Mr. **Dunn**. One question, then. You mentioned 57 American scientists, Nobel Prize winners, versus 28, from all other countries in the last 10 years.

Do you have any idea how many of those were doing research that was federally funded?

Dr. **Keyworth**. I am going to have to respond from speculation, because I do not have the facts in front of me, but I suspect that the majority of that research was either totally or in part funded by the Federal Government, because the Federal Government is the primary funder of this type of basic research.

Mr. **Dunn**. I thank you.

Mr. **Fuqua**. As I mentioned at the beginning of the hearing, Dr. Keyworth does have a meeting starting shortly and he does have to leave at 11 o'clock. We thank you.

I apologize to the other members who did not have a chance to ask questions, but we may submit some for the record and maybe you can respond.

Thank you very much for coming.

Dr. **Keyworth**. Thank you.

Mr. **Fuqua**. Our next witness is Dr. Frank Press, the president of the National Academy of Science, and former Science Adviser to President Carter.

Dr. Press?

[The biographical sketch of Dr. Press follows:]

BIOGRAPHICAL SKETCH OF DR. FRANK PRESS

Frank Press was born in Brooklyn, New York in 1924. He received his undergraduate degree in physics from the City College of New York, and advanced degrees in geophysics from Columbia University in 1946 and 1949, when he joined the Columbia faculty, becoming associate professor in 1952, working in the areas of geophysics and oceanography. In 1955 Dr. Press was appointed professor of geophysics at the California Institute of Technology, and two years later became director of its Seismological Laboratory. He was named in 1965 as the head of the then Department of Geology and Geophysics at the Massachusetts Institute of Technology (MIT), which, under his leadership, expanded into planetary sciences, oceanography, interdisciplinary studies, and the joint program with the Woods Hole Oceanographic Institution, and was renamed the Department of Earth and Planetary Sciences. In 1977 he was appointed by President Carter as the President's Science Advisor and Director of the Office of Science and Technology Policy. In January, 1981, he returned to MIT where he was appointed Institute Professor, a title MIT reserves for scholars of special distinction. Dr. Press has been elected as the 19th President of the National Academy of Sciences (NAS), where he will assume his new office on July 1, 1981.

Dr. Press is recognized internationally for his pioneering contributions in geophysics, oceanography, lunar and planetary sciences, and natural resource exploration, but his primary scientific activities have been in seismology and the study of the earth's deep interior. Recognizing the importance of long-period surface waves in studying the earth's structures, he developed the theory for these waves and the instrumentation to record them. Today the analyses of seismic surface waves and free oscillations are among the most powerful techniques for studying the structure and properties of the earth's crust and deep interior. Dr. Press also saw the need to develop techniques for geophysical studies of the moon and planets, using landed observatories. Author of 160 scientific papers, he is also the co-author of the textbook "Earth," widely used in courses in both American and foreign universities.

Dr. Press has been a leader in major national and international projects. He helped organize and gave impetus to the International Geophysical Year, the first coordinated worldwide attempt to measure and map various geophysical phenomena, a decade-long effort that involved international explorations of Antarctica and the oceans. Mt. Press in Antarctica is named for him. Dr. Press provided leadership in research efforts on earthquake prediction in the United States, and in international cooperation with Japan, the USSR, and the People's Republic of China.

As NAS president, Dr. Press will continue a long career of public service, in addition to his distinguished scientific work. He served on the President's Science Advisory Committee during the Kennedy Administration and on the Baker and Ramo Presidential Advisory Committee during the Ford Administration. He was appointed by President Nixon to the National Science Board, which is the policy-making body of the National Science Foundation, and he also served on the Lunar and Planetary Missions Board of the National Aeronautics and Space Administration. Dr. Press participated in the bilateral science agreement negotiations with the Soviet Union, and was a member of the U.S. delegation to the nuclear test ban negotiations in Geneva and Moscow.

Major initiatives of his Washington service as OSTP Director and Science Advisor during the Carter Administration included increasing the Federal commitment to the support of basic research; the introduction of new measures to spur industrial innovation; joint research ventures involving industry, the university, and the government; and regulatory reform, particularly in improving the scientific basis of proposed regulations. Dr. Press was largely responsible for the U.S.-China scientific cooperation agreements in 1979.

Dr. Press is a member of several professional organizations, and is a former president of both the Seismological Society of America and the American Geophysical Union. He was elected to the National Academy of Sciences in 1958, the American Academy of Arts and Sciences in 1966, and the American Philosophical Society. In 1981 he was elected as a foreign member of the French Academy of Sciences. He is the recipient of numerous honors, among which are the Gold Medal of the Royal Astronomical Society, the Arthur L. Day Medal of the Geological Society, and the Bowie Medal of the American Geophysical Union. He was awarded the Department of the Interior's Public Service Award in 1971 and NASA's Distinguished Public Service Medal in 1973. Dr. Press has received 11 honorary doctoral degrees. His unique distinction lies perhaps in the dual contribution of the impact of his scientific work on the development of modern geophysics and the influence of his personal leadership in national science planning and administration.

Dr. Press is married to the former Billie Kallick of St. Louis. The Presses have two children and one grandchild.

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES, AND FORMER SCIENCE ADVISOR TO PRESIDENT JIMMY CARTER

Dr. PRESS. I am most pleased, Mr. Chairman, to have this opportunity to review with your committee the implications of current reductions in budgeted levels of support for many areas of federally sponsored research and development and the impact upon the American scientific enterprise of continuing uncertainties about future prospects for funding.

These hearings can also serve as a constructive assessment of whether these budget actions imply a change of Federal policy in this area. While Dr. Keyworth's remarks are fresh in mind, I would like to make a few comments. I admire him for the courage and enthusiasm with which he has tackled his job. It is a difficult one, I assure you.

I agree that we are the world's strongest nation, scientifically and technically, but I think the issue before us is whether or not we are doing the right things to hold that position.

I agree with Dr. Keyworth that we should protect the basic research as an appropriate Government function and that we should transfer funds from unproductive efforts into more productive scientific enterprises.

I also find merit in statements he has made elsewhere concerning the need to improve scientific instrumentation in research laboratories, particularly in the universities, and I am concerned, as he is, about scientific manpower.

But the latest science indicators show that total Federal expenditure for R. & D. in constant dollars is less in 1981 than in the late 1960's. In constant dollars, basic research budgets have shown little growth over this period.

On October 26 and 27, in collaboration with many of my colleagues, I convened a conference at the National Academy of Sciences on the Federal research and development budget for 1982 and the future. The conference has, I hope, set in motion an informed dialog between public officials and representatives of the scientific and technological community. As you have requested, Mr. Chairman, I will summarize the results of that convocation at the Academy and with your permission include in the record as an attachment to my testimony a more detailed statement on the deliberation of that conference as well as a list of the attendees including nearly 100 university officials, laboratory directors, industrial research executives, scientists, engineers, and individuals experienced in public policy.

Also present were congressional staff, including several from this committee. The conferees were briefed by the President's Director of the Office of Science and Technology Policy, a senior representative from the Office of Management and Budget, and officials of six governmental departments and agencies with major research and development programs.

The conference consensus was reached on a number of findings and conclusions. Consensus was reached by all in attendance, the industrial sector agreeing with the university and Government sector. In my testimony I will highlight only the most salient conclusions of the conference. I urge you to read carefully the attached detailed summary statement and commentary on the conference.

From these discussions emerged the following matters of considerable significance to the future health of American science.

It is clear that like other sectors of our society the nation's scientific and technological enterprise has been hurt by the problems of the economy: inflation, high interest rates, industrial stagnation.

Efforts by the Congress and recent administration to combat the effects of these ills on basic research through some real growth have unfortunately not allayed the problems. Further, as a percentage of the gross national product, national support for research and development has declined since the mid sixties.

Dr. Keyworth believes that information to be flawed, based, as it is on a controversial indicator, and it may be. Nevertheless, research support has not grown since 1967 in the face of the inflation inherent in the research enterprise. Scientific advances become increasingly expensive, so many fields of science are now especially sensitive to decreases in funding.

Instability and abrupt changes in funding also have severe negative effects. For example, these factors can cause the breakup of research teams, which take years to assemble, leading to poor use of investments in experiments involving large facilities such as accelerators, spacecraft, oceanographic vessels and other instruments.

The intrinsic relationship between the performance of basic research and the training of scientists and engineers to carry out such research, means that instability or abrupt changes in support levels also can cause future critical personnel shortages.

Conference participants were fully aware that the Nation must pass through a period of restraint in public expenditures and that the impact of this adjustment must be shared by those in the research community who receive Federal support.

At the same time, conferees underscored the necessity for recognizing that scientific research is an activity from which all sectors of society benefit. Scientific and technological advances are important to the Nation's future economic health and security, and no significant sources of support exist for the collective benefit basic research provides except the Federal Government.

It is especially noteworthy, in this regard, that expenditures in basic research have, over time, consistently produced benefits in three critical areas of national concern—public health, economic development and national security, for example, antibiotics, hybrid corn, computer memories, transistors, integrated circuits, to mentions just a few.

Participants in the conference noted increasing industrial support for research and development, including outlays for research carried out at universities. Industrial executives cautioned, however, that it was unlikely that increased industrial support of university-based research and development would offset proposed reduction in Federal expenditures announced by administration officials, and it was unrealistic to make such an assumption.

Moreover, it was further noted that industry will likely focus its support on a few fields or disciplines. Only the Federal Government provides across-the-board support in basic research and this has long been accepted as a legitimate role.

In recognition of those long-accepted principles of the Federal role in support of research and development, conferees concluded that if further reductions are required in the President's fall budget program, this process should not involve a simple across-the-board cut in all budgetary accounts.

They proposed alternatively that the administration and the Congress should:

Make budgetary adjustments that maintain support of the basic sciences by reallocating funds between research and development, and between agencies;

Instruct the agencies to maintain the strength of science in agency budget allocation;

Direct that a larger part of increases in the national security budget be applied to the funding of basic research essential to the maintenance of that security; for example, in the computer sciences or solid state physics;

In recognition of the importance of the Nation's scientific and engineering manpower pool, continue graduate student support through research grants, fellowships and traineeships;

Recognize the need to revitalize the instrumentation and facility base on which future scientific and technological advance depends.

Mr. Chairman, a recurring theme throughout these discussions was recognition that the Nation's scientific base has suffered more than a decade of neglect with little or no real growth, and that the above steps are essential to maintain the competence of staff and the quality of work being performed in the Nation's laboratories.

The conferees also called for the initiation of an evaluation of the institutional system for supporting research and development—Government laboratories, the Federal funded research centers, and the universities.

I suspect that the first major concern that must be dealt with is one of credibility, that is, the growing uncertainty within the scientific and technological community about the Federal Government's long-term objectives for supporting fundamental research. A series of events extending back for a number of years has led to the current climate of confusion and uncertainty. Federal support of basic scientific research in constant dollars has remained static since 1967. The instruments for research and the laboratories are aging; attempts to recognize and ameliorate the problems have not met with success. During the past year support for social and behavioral science research was specifically targeted for reductions, suggesting policy decision to reduce the Federal role in these areas of research.

The Federal role in support of science education has been brought into question. And budget cuts are proposed for fiscal year 1982 and 1983. Hopefully, we will see a call for improved quality rather than elimination of programs.

If these reductions are actually imposed at significant levels or without a sense of priorities (for example, greater emphasis on research rather than on certain appropriations for development, support for more productive rather than less productive institutions, et cetera), damage could occur to the very institutions which have kept U.S. science preeminent over the last four decades.

The major circumstances leading to erosion of Government support are well-known: diversion of resources to support the war in Vietnam, impact of spiralling inflation, and the growing demands of an ever-increasing array of Federal programs for a larger share of the Federal budget.

These factors alone, however cannot fully explain the current anxiety that exists over the future of American science. In the current and recent administrations, knowledgeable officials have testified to the continuing health of American science. Certainly these statements have a basis in fact. We publish a substantial share of the world's scientific papers and our scientists are recognized as leaders in most scientific disciplines. The capabilities of American laboratories continue to contribute at the growing edge of innovation in most scientific areas and American scientists continue to receive the overwhelming share of Nobel prizes. Even though American technology increasingly has been challenged by other industrial nations, our leadership in fundamental research remains the world standard of excellence.

I think that is the point. If you ask the Nobel prize winners, as your committee has done, to compare the manner of doing science, the environment for conducting scientific research today to those days when they were the most productive, I think you will learn that they have serious concerns about the current environment for research.

Perhaps the greatest anxiety of those engaged in our scientific and technological endeavors stems from the increasing difficulty of maintaining this enterprise with a nearly static level of constant dollar funding.

The ability of the Nation's scientists and engineers to contribute their full potential is impeded under these circumstances. Many high quality investigators are denied sufficient support; many outstanding research proposals are not funded at all; often the time period of grant support is inadequate to permit successful project completion; as a result, training the next generation of scientists and engineers has suffered.

At the same time, indirect costs of research, the increasing burden of responding to governmental administrative requirements, and associated difficulties in funding higher education have cut heavily into the absolute amounts available for actual research.

If these conditions describe a steady trend of events in the course of our national affairs, then indeed a substantial basis exists for the anxieties manifested by the scientific community concerning how long American science can sustain a position worthy of our great Nation.

Mr. Chairman, for 15 years we have professed to recognize the importance of Federal support of science, but have not acted on that recognition in an organized, carefully thought out manner.

Today, we should (a) first recognize that our efforts do not comport with a policy of continued strengthening of the Nation's S. & T. base, and (b) seek, either to implement that policy, or face the alternative policy options with which we must grapple in a time of static or declining Federal support of science. These alternative policies could place unforeseen stress and dislocation upon an endeavor in which some growth is vital to the exploration of new opportunities.

My hope, of course, is that we are experiencing a temporary constraint upon public expenditures for science during a finite period of fiscal austerity and that these constraints are imposed within a strategy of minimizing damage. However, after 15 years of no real growth in the support of R. & D., I am not sanguine about such a temporary state of affairs. Certainly, the trend is not easily reversible unless the President and the Congress cooperate to rekindle the Nation's enthusiasm and support of the scientific and technological innovations that offer opportunities for new discoveries, new industries, solving national problems, and fostering our social and economic well-being.

Some years ago, in 1978, I had occasion to ask a number of public officials to identify outstanding research questions including those with prospective significance for contemporary social problems and issues. The list of responses, attached as an appendix, well illustrates the consequences that could flow from continued vigorous support of basic research by Government agencies and by industry and business.

Let me cite some examples of the questions on the unfinished agenda in science that adequate funding might enable us to tackle. Can we discover antiviral agents to combat viral diseases—drugs that would have as important an effect on mankind as did the discovery of antibiotics. Such a discovery would also provide a better understanding of how cells minimize mutations under normal and imposed environmental stress. What are the mechanisms by which hormonal substances reduce growth? What are the matter and energy mechanisms of stars, quasars, pulsars, black holes? Can materials be found that exhibit superconductivity at room temperature? How can we enhance productivity by automation and artificial intelligence? Can new materials be developed that would lessen our dependency on critical or strategic elements? These are the kinds of issues we might tackle with adequate support of our scientific enterprises.

The conference held at the Academy on October 26 and 27, and your hearings, which will undoubtedly extend into the next session, can begin the dialogue needed to address the uncertainties faced by our scientific and technical enterprise and offer us the opportunity to bring a greater measure of stability to the budgetary process. It is in that vein that I offer for your consideration a series of recommendations to aid in restoring program stability and predictability to our national scientific enterprise. These recommendations, if followed, would go far toward reaffirming our commitment to the policy that continued sound investments in fundamental research by the Federal Government are essential to our national goals. I present them to assist in establishing a planning framework for your committee's consideration and debate as you pursue the task at hand.

I propose a 10-year compact among Government, industry, and universities to establish new national goals for support of science as follows:

(a) The basic scientific research budget for the Federal Government should increase each year at a rate that would cover inflation and permit 1 or 2 percent real growth. This annual rate of increase would respond to the need for stability and predictability in establishing long-term planning goals and also provide for the intrinsic inflation in the costs of doing science as new methods and techniques emerge. This might be considered the base program for all scientific fields.

(b) In addition, another 1 percent annual increase should be provided to support special targets of opportunity in particular fields, or for areas of research related to particular national needs, and to provide supplementary funding to assist in meeting costs for essential instrumentation and plant facility needs. This would be a means of assigning high priority to certain significant fields in which the pace of discovery is particularly swift.

(c) The scientific community and the Government will cooperate to find ways of transferring funds from the less to more productive areas or institutions supported by Federal research funds. By cutting indirect costs, reducing regulations, and improving efficiency through longer-term awards, it would be reasonable to expect an increase in annual productivity equivalent to as much as 2 percent support.

(d) Industry should commit to 1 percent growth that is about $50 million/year, on top of its present contribution to university research in recognition of the tremendous boon that industry receives from this kind of research.

(e) To assure continuation of adequate support of graduate education in science and technology, a cooperative partnership including Government, industry, and universities is proposed. Under such an arrangement:

(1) The NSF and the mission agencies would support a coordinated program of national research fellowships and traineeships. NSF would provide support for an overall program of merit, much along the lines of the current activity, mission agencies would complement the NSF program by establishing fellowships to encourage careers in areas where special scientific and engineering manpower needs exist, such as toxicology (EPA), combustion science and engineering (Energy), and computer sciences and integrated circuits (DOD, NSF).

(2) Industry would be encouraged to establish additional fellowships in fields where its needs are greatest. Recipients could be selected in collaboration with a Federal agency, such as the NSF or by an independent group to insure a national competition of merit.

A compact between Government, industry, and the universities, encompassing the above initiatives, could assure the stability, predictability, and real growth needed for a strong U.S. effort in science and technology. It need not be an expensive program, somewhere on the order of $600 million per year, if some astute transfers are made from development to research in the overall Federal research and development budget. That is the equivalent of two B-1 bombers.

I would recommend, Mr. Chairman, that responsibility for carrying out these initiatives, especially the last two items, which require close surveillance and comprehensive overview, should be assigned to the Director of the Office of Science and Technology Policy.

The approach I have recommended recognizes that a strong scientific and technological enterprise is closely bound up with our status as a great nation, with a healthy society and a strong economy. This approach also reinforces our existing practice of relying upon support of individual research projects and shared responsibility between the public and private sectors for the performance of fundamental research.

The pluralistic nature of this institutional arrangement has given us a flexible system of research and development and has provided the incentives for individual excellence. I urge that we continue the basic system which has served us well over the past several decades, but also introduce modifications and improvements that the times require.

Thank you, Mr. Chairman.

[The statement of Dr. Press follows:]

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

I am most pleased, Mr. Chairman, to have this opportunity to review with your committee the implications of current reduction in budgeted levels of support for many areas of federally sponsored research and development, and the impact upon the American scientific enterprise of continuing uncertainties about future prospects for funding. These hearings can also serve as a constructive assessment of whether these budget actions imply a change of Federal policy in this area.

On October 26-27, in collaboration with many of my colleagues, I convened a conference at the National Academy of Sciences on the Federal Research and Development Budget for 1982 and Future Years. Although this convocation called together members of the scientific and technological community to address the problems arising from reductions in and uncertainty about current Federal support of sciences, its purpose also was to survey circumstances of the past fifteen years, which have seen no growth in funding of scientific research and government funded R&D, during a period in which the intrinsic costs of doing science continue to increase. The conference has, I hope, set in motion an informed dialogue between public officials and representatives of the scientific and technological community. As you have requested, Mr. Chairman, I will summarize the results of that convocation at the Academy and with your permission include in the record as an attachment to my testimony a more detailed statement on the deliberation of that conference as well as a list of the attendees.

The conference attendees included nearly 100 university officials, laboratory directors, industrial research executives, scientists and engineers, and individuals experienced in public policy. Also present were Congressional staff, including several from this committee. The conferees were briefed by the President's Director of the Office of Science and Technology Policy, a senior representative from the Office of Management and Budget, and officials of six governmental departments and agencies with major research and development programs. At the end of the conference, a consensus was reached on a number of findings and conclusions. In my testimony, I will highlight only the more salient conclusions of the conference. I urge you to read carefully the more detailed summary statement and commentary on the conference attached to my testimony.

From these discussions emerged several matters of considerable significance to the future health of American science. It is clear that like other sectors of our society the nation's scientific and technological enterprise has been hurt by the problems of the economy -- inflation, high interest rates, industrial stagnation. Efforts by the Congress and recent Administrations to combat the effects of these ills on basic research through some real growth have unfortunately not kept pace with the problems.

Further, as a percentage of the Gross National Product, national support for research and development has declined since the mid-1960's.

Because of lack of real growth in research support over the years in the face of the intrinsic inflation inherent in the research enterprise, many fields of science are now especially sensitive to decreases in funding.

Instability and abrupt changes in funding also have severe effects. For example, research teams, which take years to assemble, are broken up and investments in experiments involving large facilities such as accelerators, spacecraft, oceanographic vessels and other instruments are poorly used. Because of the intrinsic relationship between the performance of basic research and the training of scientists and engineers to carry out such research, instability or abrupt changes in support levels also can lead to future critical personnel shortages.

The participants in the conference were fully aware that the nation must pass through a period of restraint in public expenditures and that the impact of this adjustment must be shared by those in the research community receiving Federal support. At the same time, they underscored in their discussion the necessity for recognizing that scientific research is an expenditure from which all sectors of society benefit, that scientific and technological advances are important to the nation's future economic health and security, and that there are no significant sources of support for such a collective benefit other than the Federal Government. It is especially noteworthy, in this regard, that those expenditures in basic research have, over time, consistently produced benefits in three critical areas of national concern -- public health, economic development and national security.

Participants in the conference noted that industrial support for research and development was increasing, including outlays for research carried out at universities. Industrial executives cautioned, however, that it was unlikely that increased industrial support of university-based research and development would offset proposed reduction in Federal expenditures announced by Administration officials, and it was unrealistic to make such an assumption. Moreover, it was noted further that industry will likely focus its support on a few fields or disciplines. Only the Federal government provides an across-the-board support in basic research; and this has long been accepted as a legitimate role.

Since basic science and engineering are long-term investments, the conferees urged that the government plan carefully for their support and that such plans be protected from abrupt change.

In recognition of those long accepted principles of the Federal role in support of research and development, the conferees concluded that if further reductions are required in the President's Fall Budget Program, this process should not involve a simple across-the-board cut in all budgetary accounts. The conferees proposed alternatively that the Administration and the Congress should:

-- Make budgetary adjustments that maintain support of the basic sciences by reallocating funds between research and development, and between agencies;

-- Instruct the agencies to maintain the strength of science in agency budget allocation;

-- Direct that a larger part of increases in the national security budget be applied to the funding of basic research that is essential to the maintenance of that security;

-- In recognition of the importance of the nation's scientific and engineering manpower pool, continue graduate student support through research grants, fellowships and traineeships;

-- Recognize the need to revitalize the instrumentation and facility base on which future scientific and technological advance depends.

Mr. Chairman, a recurring theme throughout these discussions was recognition that the scientific base of the nation has suffered a decade of neglect with little or no real growth, and that the above steps are essential to maintain the competence of staff and the quality of work being performed in the nation's laboratories.

In viewing the future beyond 1982, the conferees called for acceptance by the government of several principles. It was agreed that a strengthened mechanism is needed through which the scientific and engineering communities can provide continuing advice to the government on resource allocation and assist in the analysis of the impact and benefits of alternative shorter and longer term budget strategies for government investment in science and engineering.

The conferees also called for the initiation of an evaluation of the institutional system for supporting research and development, including the mechanisms for allocating resources and evaluation of the need for some facilities. Finally, the conferees urged that policies at all levels of government should be established which will assure the continued flow of an adequate supply of scientists and engineers into the nation's research endeavors.

Mr. Chairman, it appears to me that we must once again reaffirm the credo so aptly outlined in the 1945 report, Science, The Endless Frontier, that the advancement of science is unquestionably in the public interest and that support of basic research is a legitimate responsibility of government. The question faced by the Administration and the Congress is not whether we support research, for that decision lies behind us. Today, the question involves a search for redefinition of the means and mechanism for determining appropriate levels of support under current and future fiscal circumstances.

I suspect that the first major concern that must be dealt with is one of credibility, i.e., the growing uncertainty within the scientific and technological community over what are the present long-term objectives of the Federal government for supporting fundamental research. A series of events extending back for a number of years has led to this current climate of confusion and uncertainty. Federal support of basic scientific research in constant dollars has remained static since 1967. The instruments for research and the laboratories are aging and various attempts to recognize and ameliorate the problems have not met with success. During the past year support for social and behavioral science research was specifically targeted for reductions, suggesting an implicit policy decision to reduce the Federal role in these areas of research. The Federal role in support of science education has been brought into question. Hopefully, we will see a call for improved quality rather than elimination of the program. Added to these are the proposed reductions for fiscal year 1982 and for further rounds of budget cuts in fiscal year 1983. If these reductions are actually imposed at significant levels or without a sense of priorities (e.g., greater emphasis on research rather than on certain appropriations for development, support for more productive institutions, etc.), damage could occur to the institutions of science, which have made the U.S. preeminent over the past four decades.

The major circumstances leading to the erosion of this support are well known. The diversion of resources to support the war in Viet Nam, the impact of spiralling inflation and the growing demands of an ever-increasing array of Federal programs for a larger share of the Federal budget. This situation cannot of itself fully explain, however, the current anxiety that exists over the future of American science. In the current and recent Administrations, knowledgeable officials have testified to the continuing health of American science and certainly these statements have a basis in fact. We publish a substantial share of all scientific papers and our scientists are recognized as leaders in most scientific disciplines. The capabilities of American laboratories continue to contribute at the growing edge of innovation in most scientific areas and American scientists continue to receive the overwhelming share of Nobel prizes. Even though American technology increasingly has been challenged by other industrial nations, our leadership in fundamental research remains the world standard of excellence.

However, responsible leadership requires not only recognition of our present position but also trends which might cause serious erosion. In spite of our apparent strength, there remains an underlying uncertainty about our national scientific endeavor considered in the broader context of other social and economic troubles. There are many manifestations of these trends. First and foremost are the economic pressures of the ever-increasing technological competition of other industrialized nations. Added to this are the worldwide rise in petroleum prices and the inability of domestic petroleum production to keep apace of domestic consumption. There is some public concern, less today than a decade ago, about the risks and hazards arising from the uses of technology. I believe there is growing public recognition of the social and physical amenities, which science and technology have provided to our society.

Perhaps the greatest anxiety of those engaged in our scientific and technological endeavors stems from the increasing difficulty of maintaining this enterprise with a nearly static level of (constant dollar) funding. The ability of the nation's scientists and engineers to contribute their full potential is impeded under these circumstances. Many high quality investigators are denied sufficient support; many outstanding research proposals are not funded at all; often the time period of grant support is inadequate to permit successful project completion; as a result of all of this, training of the next generation of scientists and engineers has suffered. At the same time, the indirect costs of research, the increasing workload burden of responding to governmental administrative requirements, and the associated difficulties in the funding of higher education have cut heavily into the absolute amounts available for actual research.

If these conditions describe a steady trend of events in the course of our national affairs, there is a substantial basis for the anxieties manifested in many parts of the scientific community about how long American science can sustain a position worthy of a great nation such as ours.

Mr. Chairman, for fifteen years we have professed a policy recognizing the importance of Federal support of science, but have not acted on it in an organized, well thought out manner. Today, we should (a) first recognize that our best efforts have not kept pace with a policy of continued strengthening of the nation's S&T base, and (b) seek, either to implement that policy, or face the alternative policy options with which we must grapple in a situation of static or declining Federal support of science. The implication of this latter alternative can place unforeseen stress and dislocation upon an endeavor in which some growth is vital to the exploration of new opportunities.

A basic dilemma that we face under a policy of reduced budgets for science and technology is a conflict between assuring support for the highest quality scientific endeavors and at the same time supporting broader national goals of strengthening academic capability for science at all levels throughout the nation. I will recall for you the instructions of former President Johnson in a 1965 statement to his cabinet on this subject. He said:

> "At present, one-half of the Federal expenditures for research go to 20 major institutions, most of which were strong before the advent of Federal research funds. During the period of increasing Federal support since World War II, the number of institutions carrying out research and providing advanced education has grown impressively. Strong centers have developed in areas which were previously not well served. It is a particular purpose of this policy to accelerate this beneficial trend since the funds are still concentrated in too few institutions in too few areas of the country. We want to find excellence and build it up wherever it is found so that creative centers of excellence may grow in every part of the nation."

These remarks enunciated a policy of continuing growth in Federal research very shortly before annual support levels for science reached their peak level. Under that policy the Federal Government supported not only the best of the scientific enterprise but as well the relatively next best, all in order to achieve a wider geographic distribution. American science has, of course, always been performed by a wide array of institutions. Basic research is carried out in universities, industrial and governmental laboratories and by nonprofit organizations and has been supported by private foundations, by industry and by government. Underlying this policy is the belief that improvement in the quality of American science is closely tied to widespread use of public funds to support the scientific enterprise. Such a practice was possible with a budget support policy of general growth in Federal expenditures.

I submit, Mr. Chairman, that under today's circumstances of financial austerity and the growing national consensus that this may prevail for some years, it may be necessary to reexamine this pluralistic cornerstone of Federal science policy. Under continuing tight budgetary constraints, if American science is to continue in a productive and healthy patt[illegible]e consider essential for maintaining our comparative technologi[illegible]ength, a reevaluation may be required of the compromise between egalitarianism and elitism that has characterized past Federal funding policy for science. Such a compromise may no longer be realistic. However, the consequences of such a reevaluation can, as you may well imagine, create great stress within the American scientific enterprise.

My hope is, of course, that we are experiencing a temporary constraint upon public expenditures for science during a finite period of fiscal austerity. I hope that these constraints are imposed within a strategy of minimizing damage. However, I am not sanguine about such a temporary state of affairs after fifteen years of no real growth in the support of research or R&D. Certainly, the trend is not easily reversible unless the President and the Congress jointly cooperate to rekindle the nation's enthusiasm and support of the opportunities that scientific and technological innovations offer for new discoveries, new industries, solving national problems and fostering our social and economic well-being.

There is no need for me to address to this Committee a detailed justification for why the health of science and the well-being of our society are closely linked. In your deliberations you are constantly made aware of the contributions that research and technological applications have made to economic and social progress and of the remarkable panorama of scientific frontiers in which U.S. scientists are effectively engaged in exploration. Much has been accomplished, but the major fields of science continue to offer many opportunities for fruitful investigation.

Some time ago, in 1978, I had occasion to ask a number of public officials to identify some outstanding research questions including those with prospective important relationships to contemporary problems and issues in society. That list, which is attached as an appendix, well illustrates the consequences that could flow from the continued vigorous support of basic research by many agencies of the government and by our nation's industries and businesses.

The frontiers in science remain exciting. Many of these frontiers have been aptly described in the first and second Five-Year Outlook reports submitted by the Academy for the Administration and the Congress.

I would like to cite from the summary observation of the just released publication of Outlook II, examples of the excitement that pervades many areas of science, not only because of the remarkable success of our scientific endeavors in extending the frontiers of knowledge but also in terms of scientific contributions to the spawning of new industrial enterprises.

"The chapter on Sun and Earth describes the remarkable ingenuity, careful planning, and clever instrumentation that has been used to gain further insight into the physics of the sun and the manner in which the sun's radiations govern the properties of the gaseous layers surrounding the earth, determining their chemical composition and the nature of both the magnetosphere and the ionosphere -- with important implications for radio communication. Solar energy, a fraction of which is directly used for plant photosynthesis, is largely absorbed at the earth's surface, from where it ultimately stokes the engine which creates weather in the lower atmosphere. Nevertheless, the extent to which meteorological phenomena are determined by variations in the emanations from the sun remains uncertain."

"The chapters on Chemical Synthesis of New Materials and The Science of Macromolecules suggest that chemists have the gifts of wizards, capable of creating in the laboratory any stable chemical structure that can be imagined. The chemical properties of such newly synthesized materials are fairly predictable, but predictions of their physical properties are still somewhat chancy. Surprise is still the order of the day. Nevertheless, a sufficient basis of understanding has been established to suggest that synthetic chemistry will have an ever more productive future in tailoring molecules to order for the diverse purposes of man."

"A recurring theme in the chapters on basic science and on technology is the way in which the findings and the instrumentation developed in one area of science find application elsewhere."

"The first Five-Year Outlook portrayed the manner in which the development of solid state physics and the computer and communications industries have gone hand in hand, each stimulating and making the other possible. A not dissimilar circumstance has existed in the field related to synthetic polymers and their various applications in fibers and plastics."

"As indicated in the chapter, Directions in Nutrition Research, much of our current understanding of the functioning of vitamin D is traceable to decades of work on the stereochemistry of organic molecules, on the kinds of molecular rearrangements occasioned by the absorption of light, and on the diverse physical instrumentation now employed to help decode the structure of molecules. Or note the statement in the chapter, On Some Major Human Diseases, describing the kaleidoscopic interchange of ideas from one research area to another:

> 'Who could have predicted...that studies of the genetics of skin transplantation in mice would provide a principal clue to understanding rheumatoid arthritis in man; that a variant in the structure of the sulfonamides developed as antibacterial agents would make possible management of glaucoma of the eye, or that the combination of a viral infection and inappropriate formation of an antibody to some structure on the surface of one's own cells could give rise to a family of diverse diseases?'"

"Such interweavings occur no less in the physical sciences and in the development of new technology. For example, the theory of plate tectonics provides a meaningful framework for resource exploration of commercially useful minerals and hydrocarbons. Yet this great new synthesis of geophysical understanding owes its creation to the curiosity of paleontologists about the shell structures of almost microscopic creatures found in cores drilled in the ocean floor, to painstaking surveys over the ocean floor to detect magnetic polarities in seabed rocks, to inquisitiveness about the geography of the Hawaiian Islands, to matching the flora and fauna in different continental borders, to a maze of work on the properties of chemical isotopes, and to the imaginative application of that work to the dating of ancient rocks and sediments."

"It is an inspiring fact that lasers, invented out of the insights afforded by quantum physics, have spawned new arts and technologies. They enable much more precise alignment of untold different physical arrangements, including tunnels build under riverbeds or drilled through mountains. Lasers are the basis for one approach to controlled fusion, are used to repair damaged retinas, and are at the heart of the instrumentation which makes possible the detection of fleeting intermediates in chemical syntheses. They also are used to drive photochemical synthetic processes in the laboratory and may soon find similar commercial application."

"In sum, the scientific enterprise will be seen as an extraordinarily dynamic system. The practitioners of each field successively attack in increasingly sophisticated fashion the layer of questions revealed by previous research. In the process, they find new surprises and unsuspected arrangements which generate more question as well as more opportunities for applications to human welfare."

It is evident from this survey that American science is a system with tremendous potential for expanded scientific productivity. The concerns and doubts addressed in my remarks today are associated primarily with the ever-widening margins between increasing costs of doing science and levels of funding made available for this purpose.

The conference held at the Academy on October 26 and 27, and your hearings, which will undoubtedly extend over into the next session, can begin the needed dialogue for addressing the uncertainties faced by our scientific and technical enterprise and offers to us the opportunity for bringing a greater measure of stability to the budgetary process. It is in that vein that I offer for your consideration a series of recommendations to aid in restoring an order of program stability and predictability to our national scientific enterprise. It should go far towards reaffirming our commitment to the policy that continued sound investments in fundamental research by the Federal government are essential to our national goals. I present these recommendations to assist in establishing a planning framework for your committee's consideration and further debate as you return next year to the task at hand.

I propose a ten-year compact between government, industry and universities to establish new national goals for support of science as follows:

(a) The basic scientific research budget for the Federal government should increase each year at a rate that would cover inflation and permit 1% or 2% real growth. This annual rate of increase would respond to the need for stability and predictability in establishing long-term planning goals and also provide for the intrinsic inflation in the costs of doing science as new methods and techniques emerge. This might be considered the base program for all scientific fields.

(b) In addition, another 1% annual increase would be provided to support special targets of opportunity in particular fields, or for areas of research related to particular national needs, and to provide supplementary funding to assist in meeting costs for such items as essential instrumentation and plant facility needs. This category may be considered a means of assigning high priority to certain fields in which the pace of discovery is particularly high and significant.

(c) Within present levels of program support, the scientific community and the government will cooperate to find ways of transferring funds from the less productive areas or institutions now supported by Federal research funds to the more productive ones. Increased productivity could be accomplished by reducing indirect costs, reducing regulations and improving efficiency through longer-term awards. A reasonable target should have the result of increasing annual support by as much as 2%.

(d) A commitment from industry of 1% growth (i.e., about $50 million/year) on top of their present contribution to university research.

(e) To assure continuation of adequate support of graduate education needs in science and technology, a cooperative partnership including government, industry and universities is proposed. Under such an arrangement:

(1) The NSF and the mission agencies should support a coordinated program of national research fellowships and traineeships, with NSF providing support for an overall program of merit, much along the lines of the current activity, with mission agencies complementing the NSF program by establishing fellowships that

will encourage careers in areas where there are known to be special scientific and engineering manpower needs. Examples would include: toxicology (EPA), combustion science and engineering (Energy), and computer sciences and integrated circuits (DOD, NSF).

(2) Industry should be encouraged to establish additional named fellowships in fields where their needs are greatest. Selection of awardees who would be recipient of these fellowships could be managed in collaboration with a Federal agency, such as the National Science Foundation or by an independent group that would administer the fellowship program to ensure a national competition of merit.

Such a compact between government, industry and the universities encompassing the above initiatives could provide the commitment for assuring the stability, predictability and real growth needed for a strong U.S. effort in science and technology. It may seem to be an expensive program, but it need not be so, if some astute transfers are made from development to research in the overall Federal research and development budget.

It would be my recommendation, Mr. Chairman, that program responsibility for carrying out these new initiatives should be assigned as a task to the Director, the Office of Science and Technology Policy, especially with regard to the last two items, which would require close surveillance and exercise of a comprehensive overview.

I end my remarks by saying that the approach I have recommended recognizes that a strong scientific and technological enterprise is closely and intrinsically bound together with a healthy society and a strong economy. It also would reinforce our existing practice of relying upon support of individual research projects and a shared responsibility between the public and private sectors for the performance of fundamental research. The pluralistic nature of this institutional arrangement has given us a flexible system of research and development and has provided the incentives for individual excellence. I urge that we continue the basic system which has served us well over the past several decades, but also introduce modifications and improvements that the times require.

APPENDICES TO STATEMENT

PRESENTED BY

Dr. Frank Press
President
National Academy of Sciences

before the Committee on Science and Technology
House of Representatives

December 10, 1981

1. CONFERENCE ON THE FEDERAL RESEARCH AND DEVELOPMENT BUDGET FOR 1982 AND FUTURE YEARS, October 26-27, 1981 - SUMMARY
2. STATEMENT OF CONFERENCE CONSENSUS
3. LIST OF CONFERENCE PARTICIPANTS
4. BASIC RESEARCH QUESTIONS FOR WHICH SUPPORT IS DEEMED IMPORTANT TO THE NEEDS OF THE COUNTRY AS IDENTIFIED BY PUBLIC OFFICIALS IN 1978

CONFERENCE ON THE RESEARCH AND DEVELOPMENT BUDGET FOR 1982 AND FUTURE YEARS

SUMMARY

In brief, the purposes of the meeting, held October 26 and 27, 1981, at the National Academy of Sciences in Washington, D.C., were to:

- obtain factual information on federal budgetary plans for FY 1982 and beyond, from government officials directly concerned with science policy and with civilian research and development budgets;

- develop an informed dialogue among conference participants and with agency officials about the impacts of the prospective reductions;

- propose budgetary alternatives, for FY 1982 and for future years; and,

- consider initiating reviews of the institutional structures and procedures for supporting research and development in the national laboratories and in the universities.

During his welcoming remarks to the conferees, Dr. Frank Press, president of the National Academy of Sciences, stressed that he had convened the meeting because he believed all could benefit from an informed dialogue, and, secondly, that he did not view the conference as the basis for confrontation with officials representing the departments and agencies. Dr. Press also stressed that he was acting as a convenor of a number of key officials in government with leaders in research and development, and that it was not a meeting of the Academy.

On October 26, the conferees met with representatives from six governmental departments and agencies. A number of conference participants served as panelists for discussion. Comments from the floor followed each panel presentation. On October 27 the conferees met in executive session, at which time they adopted a consensus statement. [The consensus statement and the list of participants are attached.]

This summary first discusses the current and prospective budget plans, as presented by the governmental representatives and as shown in the analysis by Dr. Willis Shapley, consultant to the American

Association for the Advancement of Science. Secondly, it describes impacts -- immediate and beyond -- of the prospective budgetary reductions. Finally, it reports on possible involvements by the scientific and technical community in governmental decision making.

CURRENT AND PROSPECTIVE BUDGET PLANS

Overview of the Current Budget and Its Status

The FY 1982 budget presented by the Administration in March 1981 reduced the totals proposed for research and development by the previous Administration, but it generally maintained the principles of federal responsibility for longer-term research and those applied research and development activities that support recognized federal missions such as national security. The exception in the March budget to these principles was the severe reduction in support for basic research in the social sciences. However, in September, the Administration proposed a further reduction in the FY 1982 budget -- the so-called "12 percent across the board cut." That proposal would reduce the $42.2 billion of R&D appropriations request of the March budget by $3.1 billion -- $1.0 billion from the Department of Defense (DOD) and $2.1 billion from all other programs. Of the $42.2 billion, about $5.5 billion is ascribed to basic research and that amount would be cut by about $600 million.

In constant 1980 dollars and applying the Administration's annual inflation rate of 9%, the percentage difference between the 1980 budget and the proposed September budget is: DOD, +26%; NASA, -7%; DOE, -29%; NSF, -17%; HHS, -19% (NIH, -18%). For basic research, the overall reduction is 11%.

The present actions of the Congress on the FY 1982 appropriations requests call for reductions from the March budgets of lesser magnitude, being a reduction of about $1.0 billion from total R&D funding and taken from the DOD budget. While some other reductions have been made by the appropriations committees, there have also been increases totalling about $200 million. The Congressional actions are not complete; the government is currently operating on a continuing resolution empowering agencies to expend at levels and rates consistent with 1981 appropriations levels. The Administration, however, has further instructed agencies to expend at rates consistent with the proposed September revisions to the 1982 budget. The Administration proposes to set these levels formally through the deferral process, and deferral requests were being sent to the Congress by the Administration in late October. The resolution of the 1982 appropriation process will require much further discussion between the two governmental branches. Several participants at the October 26-27 Conference, including Administration officials, indicated that the outcome will be negotiated, and that the conferees should not assume that the 12% reduction proposals will be enacted as such.

Views of Administration Officials

The Administration, through the Executive office of the President, was represented by Dr. George A. Keyworth, director of the Office of Science and Technology Policy, and Mr. Frederick Khedouri, the Associate Director for Natural Resources, Energy, and Science in the Office of Management and Budget. Dr. Keyworth cautioned against assuming the worst possible scenario concerning the budget. He indicated that he felt that, overall, science was healthy; that the Administration would still adhere to a philosophy of supporting research; but that it would take a more critical attitude toward demonstration programs, especially where the civilian sector might be expected to do the job. He felt greater attention needed to be placed on identification of research areas of maximum promise, with the assumption that these would be supported. Maintaining the strength of top research universities, supporting high quality research, and responding to instrumentation needs were all urged by Dr. Keyworth.

Mr. Khedouri acknowledged that the budget outcome for 1982 is unclear; there will be negotiation and the gap between the Administration and Congress will narrow. The Administration's aim is to establish targets and to stick to goals; there will be active, not passive, response by the Administration to revisions of targets, by the Congress or by revised economic forecasts. This will require two to three years of hard budget decisions. He indicated that the usual budget process might have to be abridged over these years, but that the framework for research would be protected. He advanced the notion that from his perspective the issue was about a change in rate of growth of the budget rather than absolute reductions. Mr. Khedouri asserted that, overall, there was some real growth in research; and that basic science was faring well compared to demonstration and social programs. One should not assume, however, that there can be, or should be, more and more science support from the government. The scientific community could help in reallocation.

Research Agencies

The research and development leaders from NSF, NASA, and the Departments of Energy and Health and Human Services (NIH) made a number of points concerning the budget proposals, including that they are using different tactics to cope with the proposed reductions.

National Science Foundation. The NSF, for example, is attempting to shield basic research in the mathematical, physical, and engineering sciences to a greater extent than some other areas because of the underfunding over a decade in these disciplines. Dr. John Slaughter, Director of the NSF, said that the National Science Board (NSB) and key NSF executives recognize NSF's critical role in research and that in this period of tight funding the catalytic effect of NSF funding -- in prompting funding by other agencies, industry, and, other private sources -- needs exploration and emphasis. The NSF will support research in the social sciences. The statement of the NSB on the social sciences was stressed.

Further, the NSF has continued to be concerned about instrumentation and has led an interagency group considering ways to increase instrumentation funding. NSF is avoiding applying "simplistic" formulas, such as ratios of the existing grants renewed to new ones funded.

However thoughtful these tactics, there will, realistically, be significant effects on money actually available and the nature of what is funded. For example, in NSF's case, some 60 percent of its grant money is committed to projects having another year or more to run.

National Aeronautics and Space Administration. NASA is terminating, or grossly reducing, specific programs, rather than applying across-the-board cuts. Which program to cut is a derivative of several variables, including the long-term gain for science generally as, for example, the broad gain in astronomy promised by the orbiting later this decade of the Space Telescope. Hans Mark, Deputy Administrator of NASA, made several comments about the budget situation. It is only partly true that Shuttle costs are reducing funding for science. There are severe problems of inflation, exacerbated by the lack of technical craftsmen and skilled workers, affecting not only the Shuttle but all aerospace procurement, e.g., Atlas Centaur launch vehicles. NASA recognizes that procurement and development costs associated with the Shuttle obscure other elements of the budget and has sought and received from OMB an agreement that the Shuttle be budgeted separately from the rest of the agency's programs.

NASA has told OMB that it cannot operate a planetary program with only one project each decade, and that this activity should be supported properly or not at all. Other research missions, e.g., aeronautics research, are being viewed in a similar fashion. Mark said that he and Administrator Beggs want the advice of the scientific community. With regard to cooperative missions, such as the Solar Polar Mission, it was difficult to generate diplomatic support, since in the broader context many agreements are honored neither by the United States nor by the Europeans. Mark shared the frustration of Loosing support for projects with interagency funding, such as the National Oceanic Satellite System, and the difficulty of turning the high public interest in space into political and budgetary strength for the program.

The Department of Energy. The budgetary situation in the DOE is complicated by the announced plan of the Administration to abolish the department. There are no decisions and Dr. Alvin Trivelpiece, Director of the Office of Energy Research, reported no emerging preferred alternatives. At present, the agency plan is to effect a percentage reduction across all elements of the department, including the large commercial-scale demonstrations, the basic energy sciences, and the high-energy physics programs.

The Energy Research Advisory Board has begun to look at the future roles of the national laboratories. DOE recognizes that universities use some facilities of the national laboratories, such as computers. The twin uncertainties of DOE funding in the basic sciences and the future of the Department are severely hampering the ability of laboratory directors and individual scientists to plan research programs.

Department of Health and Human Services. Dr. Edward Brandt, Assistant Secretary for Health, in summarizing the situation at NIH, said that he recognizes that the proposed budget reduction will severely affect the policy of supporting an adequate number of new research grants each year and training clinicians for research careers; it will certain affect NIH's special responsibility in biomedical research. Moreover, Dr. Brandt acknowledged that the current year cut was severe because of the commitments to continuing grants, and that level or reduced funding would affect basic biomedical research. Over several years, the impact of reduced budgets could be severe and the current goal of 5000 new awards each year could not be met. He offered no solutions. The Department is not planning for drastic responses to the proposed budget reductions, e.g., elimination of an NIH institute, because of the low likelihood that such a step would be sustained.

Department of Defense. From a cross-agency perspective, there is little likelihood that reductions in basic research funding will be offset, wholly or in part, by increases in DOD funding for basic research. The reasons include the uniqueness of the DOD mission and, more heavily, the several years of constrained spending that DOD now wishes to recoup. DOD increases will be scrutinized by Congress; further, sustaining basic research under the combined pressure, of anticipated reductions in the rate of growth of the DOD budget and new or intensified development programs will be difficult.

Other Agencies

It was noted that the effects of the costs extend not only to the immediate plans of the larger, more visible R&D agencies, but may be -- in fact, are, -- more severe for the smaller agencies; for example, a proposed 50 percent reduction in EPA's research budget; a 15 percent cut in NOAA's budget, and so forth. A danger is that in the effort to restore funding for the more prominent research agencies that those severe cuts in the smaller, less visible agencies may be sustained.

It was also noted that some research is the result of "piggybacking" and may be lost through what seem, on first order, to be non-research cuts. This piggybacking is particularly illustrated in the social sciences: demographers in census, economists in assembling national economic accounts, anthropologists in international exchange programs, and so forth depend on other programs as the framework for their research efforts. As these activities are reduced in scope, the effect on social science research will be severe.

IMPACTS: IMMEDIATE AND BEYOND

The effects of federal budget reductions -- namely the proposed September levels -- can be examined in several ways: by the effects on the basic research enterprise, per se; by the effects on national goals, including national security, improved productivity, availability of adequate number of scientists and engineers, and by the ability of the industrial R&D endeavor to offset reductions in federal R&D work and support. These and many other effects were addressed by many of the conferees. A number of the major points made by conferees are summarized below.

Effects on the Basic Research Enterprise

American science, especially its basic research component, is now appraised as generally healthy. However, slippage has been taking place in recent years. That is revealed in several ways, such as the erosion, vis-a-vis other research nations, of the historic American leadership in high energy physics and in astronomy. Virtually no part of a decadal strategy for space science research prepared in 1975 has been done. X-ray astronomy may in future years be dominated by observational work of European and Japanese Astronomers. Other nations will be sending missions to Halley's Comet; the U.S. will not. In high-energy physics, Europeans are leading in reporting experimental results, and, with the money invested in new European facilities, that dominance will continue and probably widen. In any case, the implications of reductions in basic research support need to be faced early. Sustained reductions over several years will lead to a major change in the U.S. position vis a vis European nations and Japan.

Some participants in the conference did not share the view that the research enterprise was generally healthy and stressed that it is more fragile than planners in Washington realize. They further cited the quality of life in the laboratory here and the contrast in laboratory working conditions and resources in the United States vis-a-vis Europe. The behavior of the funding agencies is another indicator of problems for the research enterprise. Sustained underfunding of research has many ramifications. One outcome, given prospects for further reductions in successive fiscal years, is conservatism in funding extended projects: established operations may do better; new people will be denied programs and lost. It is a misconception to say that investigators whose funding is skipped for a few years can then come back.

Some agencies by virtue of their missions are more vulnerable to current and future reductions. For example, NSF, with most of its money allocated for grants, has less flexibility in responding to cuts than does DOE, which conducts a more heterogeneous research program, one that includes not only basic science but also development and demonstration programs. While there is greater flexibility in some agencies, there are also great pressures to continue investments in large scale demonstration plants. These pressures will inevitably affect those agencies supporting longer-term research.

Some at the conference stressed the multiplier effects of budget cuts, stating that the system was in many ways taut, that small changes, up or down, in funding had pronounced impacts on all aspects of research, funding for procurement, manpower and training, and so on.

Mismatches: Budgeting and The Research System. Damage is done by the "mismatches" between the dynamics of government actions and the time constants of the research system. Government budgets change drastically, in amounts and within months. The basic research system generally operates in considerably longer time frames, typically several years; that is, the time needed to conduct an experimental program, to construct large facilities, to develop research teams that can work harmoniously and effectively, for a graduate student to complete a thesis. When mismatches occur between the timing of budget reductions or redistributions and those time constants of research, the effects can be severe -- in sunk costs lost, in incompleted theses, in aborted careers in science and engineering. The majority of research performers have no reserves; universities have less funds to support transitions between grants. The results are severe dislocations when precipitate budget changes occur. Leverage effects are a consequence of these mismatches; that is, relatively small cuts having greatly magnified effects, in research productivity and in time lost.

Instrumentation. Instrumentation of research universities is now in quite bad shape, with apparently no immediate prospects for relief. Students are using obsolescent equipment. The first of several efforts over the coming years intended to reduce this problem, a $75 million request by the NSF, was deleted in the March budget. An interagency effort to share the burden of instrumentation funding has produced an agreement among department and agencies that the instrumentation problem is serious; but, because of funding pressure, the outcome of any proposed budgetary initiative is in doubt.

Manpower. The decline in the number of Ph.D's in physics is symptomatic of difficulties in the research system, given that, at the graduate level, training and education commingle with basic research. Despite a rough doubling of the GNP (1972 dollars) since 1963 and a substantial increase in the working age population, the number of Ph.D. graduates in physics will decline in the near future to pre-sputnik levels. That decline will directly affect the country's national security; that is, in having sufficient scientific and technical talent to develop new defense technologies.

NIH training grants will be reduced substantially. Moreover, the government has no way to cope with the already evident decline in the number of physicians training for a basic or clinical research career. (Note: After the conference, the NSF fellowship support programs were reinstated by OMB in the FY 1982 request.)

National Laboratories. The budget reductions are already severely affecting the national laboratories. Given future plans, some laboratories may be virtually dismantled or greatly reduced. Unique capabilities may be irreversibly damaged; thus, the dismantling of programs in planetary science may impoverish the Jet Propulsion Laboratory, even though JPL has taught the world a lesson in quality control. The role of the national laboratories needs examination, including the nature and quality of their basic research that is done and their relations with the research universities.

Impacts on National Concerns: Productivity and National Security

Research -- basic work in the natural, social, and engineering sciences-- is the country's major investment in the future use of its resources, most directly in providing fertile ground for new technologies that amplify the value of increasingly restricted resources. Without adequate investments in intellectual capital, there may be continuing erosion in the country's ability to compete internationally in high technology. The real growth of U.S. funding of basic research over a ten-year-period has been less than that of Japan, West Germany, and France. Data on expenditures for research and development in the industrial countries, such as those contained in *Science Indicators*, were cited, and supported with first-hand observations, by both industry and academic participants. Several conferees stressed that future international competitiveness required more, not less, investment in research by the government and by industry. A continued flow of trained manpower for industry and universities requires a strong governmentally supported research effort.

There should be collaboration between government, the universities, and industry; however, attitudinal changes were necessary to a more favorable spirit of collaboration. The tax measures recently enacted will help, but, when considering both government and industry investment, it should be kept in mind that the proportion of the national resources being directed to R&D is declining in the United States in comparison to some other industrial nations. The relationships of the budget actions to defense and national security were of concern to the conferees. The effect of sustained tight budgets in basic research on manpower availability and the general knowledge base on the nation will be pronounced.

Industry Research

Industry couples directly to the basic research system in its concern with the health of graduate education; that is, in assuring the continuing production of people trained in research and fully conversant with the frontiers of fundamental science.

While a number of specific agreements between particular universities and industries exist or are being arranged, the amount of support by industry for academic research particularly and university education generally is likely to be limited. Thus, a tripling over the next decade of industrial support currently directed to university based research would about equal the proposed federal cut in R&D funding for one year. There is no indication that industry can or will have the capacity to substitute for the government's historical role in the support of basic research. It is a misconception to believe that the scale of changes being proposed in the federal funding will be offset by industry's activity on campuses or in its own laboratories. Further, it should be kept in mind that industry will likely focus its increased support of research in universities on a few fields or disciplines, such as electronics and geology.

DECISIONS: INVOLVING THE S&T COMMUNITY

As a first principle, the conferees agreed that several years of reductions in basic research funding will be damaging. However, given that overall budgetary reductions will occur in FY 1982, the issue is how to manage budget redistributions so as to protect the basic research system.

A number of the attendees at the conference asserted that a process or dialogue needed to be restored to the budget process. The root issue is participation by the scientific community itself in the decisions that are made; A measure of due process is needed. Barring that, we will get second-rate science, second-rate technology, and become a second-rate world power, said one participant. The problem to be faced, it was noted, is that the research system is now entering a negative growth cycle. How can we see to productivity in research in a period of chronic negative growth?

There is again a mismatch problem: between the day-to-day, often crisis environment of governmental decision making and the ability of the scientific community to mobilize and to prepare consentient advice. Whatever the difficulties advice and judgments -- on the quality of programs, relative importance of different fields and subsets within fields, and so forth -- are critical. NASA, for example, needs advice -- political and scientific -- as to what sort of institution it should be. Other agencies, such as DOE, don't have good standards as to what to support. For example, how many fellowships should there be and in which fields?

For its part, the research community needs sufficient notice of departures from previous budgetary trends, to allow corrections in the number of graduate students accepted, faculty positions offered, equipment purchased, major experiments, and so on. Does the government, for example, believe that "crisis budgeting," similar to the revised budget issued in September, will recur for several years?

In all, what is needed is an interactive, continuing exchange of information between the government's fiscal and science policy officers and the scientific and engineering community. No adequate mechanism to accomplish that now exists. As a corollary, there is now no apparent way to manage "an orderly retreat" from the present R&D effort, in lieu of "brute force" methods. As an example, can funds be set aside to provide for termination of grants, which, while small in amount, would lessen the dislocations of a transition, when it occurs, from full funding to no funding?

As to tactics, one way to conserve funds for basic research, to protect the enterprise, may be to combine the government's retreat from development and demonstration programs -- those efforts that private sector should do, excepting those that are so costly and long term, such as fusion, that industry cannot support them -- with increased funding for basic research.

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November 4, 1981

STATEMENT

The conference on research and development was a meeting on October 26-27, 1981, of about 100 university officials, laboratory directors, industrial research executives, scientists and engineers, and individuals experienced in public policy, who were drawn together at the invitation of Dr. Frank Press, President, National Academy of Sciences. The conferees met to discuss the impact of the prospective budget reductions proposed by the Administration upon the Nation's scientific research capabilities. Officials of the Administration discussed their proposals with the group. Observers from the staff of the Congress and the press were present. The conferees reached consensus on the following:

o The problems of the economy - inflation, high interest rates, industrial stagnation - have eroded research and development just as they have impacted other sectors of our society. The participants in the conference understand that the nation must pass through a period of restraint in public expenditures. Yet the proposed reductions in the President's September or Fall Budget will do irreversible damage unless longer term research, in contrast to development and demonstration, is protected.

o It is the view of the conference that continued sound investments in research and development by the Federal Government are essential to our national goals, including public welfare, a strong national security, and a renewal of growth in productivity. Much of our economic growth over the last three decades is directly attributable to research and development that has been supported by both government and industry and even earlier investments in research. Because of the important relationship between research, technology and increased productivity, the expressed goals of this Administration for a strong economy and improved national security demand more, rather than less investment in basic research. Furthermore, the intrinsic relation between the performance of basic research and the training of scientists and engineers makes continuing strong support necessary to prevent future critical personnel shortages.

- Within the current support by the government of research and development, nearly $40 billion, less than 15% represents basic scientific and engineering research. Support of scientific research is a public expenditure from which all sectors of society benefit. Basic science is a long-term investment, and depends on government support. There are no significant sources of support for such a collective benefit which can replace the Federal Government.

- Instability and abrupt changes in funding have severe effects: research teams are broken up; investments in experiments involving large facilities such as accelerators, spacecraft, oceanographic vessels and other instruments are poorly used. The continued flow of new researchers into our industrial and university laboratories is best maintained by their stable and continued participation in university based graduate research.

- Because of low investments in research over a decade and high inflation, many fields of science are now especially sensitive to decreases or increases in funding. The conference urges that the Government plan carefully for the support of the natural sciences, engineering sciences and social sciences, and protect such plans from abrupt change.

- In the March budget revisions the Administration recognized the general, long accepted principles of the Federal role in support of research and development. There is special concern for defense and renewed growth in productivity.

The proposed reductions in the President's Fall Budget Program would establish an overall percentage cut in all the various budgetary accounts. The conference strongly recommends instead that the Administration and Congress should:

- View research and development across the entire government, making budgetary adjustments or reductions that maintain the basic sciences by reallocating funds between research and development;

- Instruct Departments and Agencies to maintain the strength of science in agency budget allocations;

- Direct a larger part of the increased budget for national security to the funding of basic research that is essential to the maintenance of that security;

- Recognize that the scientific base of the nation has suffered a decade of little or no growth and must be strengthened in order to maintain competence in the nation's laboratories;

- Recognize that education in the sciences is inextricably linked to research and continue graduate student support through research grants, fellowships, and traineeships;

- Recognize the need to revitalize the instrumentation and facility base on which future scientific and technological advance depends.

These principles should be applied to the budget for 1982 and beyond.

- A much strengthened mechanism is needed through which the scientific and engineering communities advise on resource allocations and analyze the impacts and benefits of various shorter term and longer term budget strategies for government investment in research and development.

- It is timely to initiate an analysis and evaluation of the institutional system for the support of research and development including the distribution of resources, the continued need for some facilities, grant mechanisms, etc. There should be input into this review from the scientific and engineering communities in universities, the national laboratories and industry. Further, review must look across Departments and Agencies to achieve the most productive allocation of resources.

- The strength of the nation depends on the continued supply of scientists and engineers. A large number of the best young people must be attracted into these disciplines for careers in industry, the government, and universities. Policies at all levels of government to insure the continued flow of scientists and engineers must be developed. The education of the nation's youth in science and engineering requires priority attention not only by the Federal Government, but also by citizens and officials at the state and local levels and also by the private sector.

- The growing relation between universities and industry are laudible and the nation can only benefit from these partnerships. Yet such a relation cannot become a substitute for the strong government-university partnership in support of basic research which now exists. The industrial members of the conference strongly support the continued investment in basic research by the government.

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October 26 - 27, 1981

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BASIC RESEARCH QUESTIONS
FOR WHICH SUPPORT IS DEEMED IMPORTANT
TO THE NEEDS OF THE COUNTRY
AS
IDENTIFIED BY PUBLIC OFFICIALS
IN 1978

Attachment to the Statement of Dr. Frank Press
President, National Academy of Sciences
before
The Committee on Science and Technology
U.S. House of Representatives
December 10, 1981

Astronomy and Astrophysics

What is the nature of the universe?
How did it originate? Is it expanding, contracting or in a steady state? How large and how old is it?

Is there intelligent life elsewhere in the universe?

What are the matter and energy mechanisms of stars -- quasars, pulsars, black holes?

What is the nature of a solar flare? How is the energy stored and how is it released?

How do planets evolve and what are the common processes that shape the environments of the Earth and the planets?

How does the material pervading the universe collect to form complex organic molecules, stars, and galaxies? Research in this area can provide increased understanding of fundamental natural laws and the origins of the universe.

What is the nature of intelligence?

How do we think?

What are the individual and cumulative effects of government regulation on domestic productivity? This research will provide a sound technical basis for assessing the benefits and cost of proposed, as well as existing, government regulations.

What are the factors contolling cognitive development? For example, how can the large number of component processes involved in reading and understanding a paragraph be characterized? Research on this question should provide new knowledge on the processes involved in reading and comprehending text. Such work is important in providing a basis for improving the techniques for teaching people to read and comprehend.

What are the mechanisms responsible for sensory signal processing, neural membrane phenomena, and distinct chemical operations of nerve junctions? Research in these areas will extend knowledge of perception, behavior, and the chemical functioning of the nervous system.

What are the factors -- social, economic, political, and cultural -- which govern population growth? High population growth rates in the developing countries impose an economic burden which too often exceed the gains made by development. Social and biomedical research on safe, efficacious, and culturally acceptable contraceptives would therefore be of great benefit.

Biology and Microbiology

Can we discover anti-viral agents to combat viral diseases? The development of such drugs would have as large an effect on mankind as did the discovery of antibiotics.

What are the mechanisms by which cells repair damage to their genetic material? This information will provide a better understanding of how the cells minimize mutations as a result of normal and imposed environmental stress.

How do cells change during growth and development? Advances and understanding in this area should provide insights into the development of cell specialization and, perhaps, the aging process.

What are the molecular mechanisms by which genes are regulated to produce specialized products, and what new information is required to exploit the new DNA recombinant technology? This work may lead to improved knowledge of gene action.

Can microbiological research develop organisms which can convert crude organic materials, such as common cellulose, into livestock feed? The ability to convert common cellulose to feed-stock would significantly increase the availability of high-grade animal protein for human consumption.

What predisposing factors govern cellular differentiation and function in plants and animals? Successful research directed towards this question can provide an understanding in plants of factors responsible for drought tolerance and winter hardiness and in animals the mechanisms governing the development of fat and lean tissue.

What are the mechanisms by which hormonal substances regulate growth and reproduction in plants and animals? Answers to this vital question could help solve many perplexing problems, e.g., conception and embryonic mortality in animals and control of post-harvest ripening of fruits and vegetables.

In our eco-system affecting man and animals, how do microorganisms gain resistance to antimicrobial drugs and what mechanisms affect the maintenance and transfer of such resistance? Research to provide an understanding of bacterial resistance to drugs used in their control is essential for the protection of human and animal health.

What are mechanisms within body cells which provide immunity to disease? Research on how cell-mediated immunity strengthens and relates to other known mechanisms is needed to more adequately protect humans and animals from disease.

How can genetic improvement of crops for improved performance under stress conditions be accelerated? Research is needed to identify, more rapidly, useful gene sources for increasing photosynthetic efficiency and resistance to environmental stress.

What are the physical and biochemical factors associated with secondary cambial differentiation? The secondary cambium of a tree divides to form identical cells which are capable of becoming either phloem or xylem cells. Studies at the North Central Experiment Station are directed toward identifying the physical factors and biochemical signals which direct cambial development and differentiation. Such information will provide essential clues on the formation of wood.

How can utilization of the forest resource be enhanced through manipulations at the level of the plant cell, and through single-cell biodegradation? Tree cells can be stimulated to produce oleoresins, natural biocides, specific carbohydrates, and organic acids. Cell morphology such as fiber length can be altered to affect paper properties. Single-cell protein, hydrocarbons, acids, vitamins, steroids, and alcohols can be produced through biodegradation of tree components.

Can the microbiology of the gastrointestinal tract of man and animals be controlled? Research on this important question is needed to understand the contribution of microbial activity to general health and its effect upon nutrient utilization.

What are the quantitative differences between minimum human requirements for nutrients and those amounts needed for optimum physical, behavioral and mental functions? Research in this area will contribute to the attainment of maximum physical fitness and a longer, more vigorous, productive life.

Chemistry and Biochemistry

Combustion is older than recorded history, yet it is poorly understood in scientific terms. It is important that better understanding be achieved for all aspects of combustion, in order that our fossil fuels can be used with maximum efficiency and minimum adverse impact on the environment.

To what extent can laser-induced chemistry be used as a practical, synthetic tool? Research in this area could lead to processes for preparing pure products with a low energy input and low environmental side effects.

For many applications, solar energy is impractical because sunshine is intermittent, and energy storage is wasteful and expensive. Basic research is needed to develop ways in which sunlight can produce storable fuels. One possibility is to mimic but improve on photosynthetic processes, with emphasis on increased efficiency and products simpler than carbohydrates. Another approach is the use of sunlight to promote reactions which decompose water to hydrogen and oxygen.

The liquefaction of coal is currently done by converting the complex coal structure to simple molecules, then re-combining these into appropriate fuels. The process is capital intensive and energy wasteful. Research is needed on means to transform the coal into useful liquid fuels by a more direct route. This will involve much greater insight into the structure of coal and its reactions during the transformation process.

How do catalysts work? Research on this question can lead to more economical ways to produce hydrogen and to convert coal to useful liquids and gases.

What is the chemical basis of life? Where and how did it originate? Is a carbon-based chemistry a prerequisite for life? Does gravity play a significant role in the development and maintenance of life?

Can simple chemical reactions be discovered that will generate visible radiation? The results of research on this question may lead to inexpensive lasers for communication and industrial uses.

Can new homogeneous catalysts be prepared that will catalyze chemical processes important to the chemical industry? Research in this area could make it possible to make specific molecules needed in industrial processing techniques with minimum energy expenditure and without the creation of unwanted molecules that may pollute the environment.

How do enzymes work? This research should help discover how enzymes selectively catalyze and control the chemical reactions carried out by living systems. The results of this research should extend knowledge on how to synthesize molecules in living cells.

What mechanisms of herbicidal action, at the cellular level, are responsible for weed-killing effectiveness? Understanding these mechanisms is essential to improving technologies for reducing the $6 billion annual crop losses caused by weeds.

To what degree can conventional chemical pesticides be replaced by novel chemicals such as pheromones and insect growth regulators for forest insect pest suppression? Development of such chemicals would provide means of protecting the timber resource with minimal adverse environmental effects.

Earth, Oceans and Atmospheric Sciences

At what rate will atmospheric carbon dioxide concentrations increase as a result of increased use of fossil fuels? What effect will increasing carbon dioxide levels have on climate? How will this change the global social, economic and political structure? How might the impact be ameliorated?

Can a predictive capability be developed regarding geochemical transport processes in the accessible regions of the earth's crust? Successful research directed toward this question would have major impact on expansion of the Nation's resource base, and would be of vital importance in resolving waste (nuclear and non-nuclear) problems.

What is the nature of climate? What are the processes that control climate? How far into the future can you predict it? Is our climate warming or cooling? How far in advance can you predict weather, climate? Is there a relationship between climate and solar activity and, if so, what is the physical connection?

What are the physical processes that govern climate? Greater understanding of climate could aid in the prediction of climate changes and allow time for measures to offset their impact.

To what extent is the stratospheric ozone affected by contamination of long-lived, man-made chemicals? The results of this research are important to man's survival and to the future of major industries.

What is the petroleum potential of the continental slopes and the adjacent ocean floor beneath deeper waters? This work is helping to identify the resource potential of the ocean's floor beyond the OCS.

How do organisms in the deep sea influence the productivity of the ocean? How will they react to sea floor dumping and mining activities? Answers to these questions will aid in assessing the future of the ocean as an important food source and should also provide baseline data on contamination of the sea.

Can research into the processes by which mineral deposits were formed in the earth's crust be sufficiently aided by deep ocean floor investigations so that mineral resources can be more efficiently located on land or sea-bed? Research which would improve the success-rate of exploratory efforts could be of considerable advantage.

What improvement in understanding of oceanic and atmospheric effects on climate can be gained by increased use of sophisticated technology, such as satellites, in observing air/sea interactions? Air/sea interaction is particularly important in pursuing the promise of regional seasonal climate prediction and in determining the role of the ocean as the major absorber of atmospheric carbon dioxide (with implications for the fossil-fuel energy future).

What physical processes govern the interaction between high energy plumes and the ambient atmosphere? Research in this area is needed to improve air pollution models and forest fire forecasts.

Economics

What is the economic and technical potential for saving energy in the processing and marketing of agricultural commodities?

What are the potentials for per capita energy saving and improved levels of living for alternative sizes and population densities of communities in the United States?

Despite continued long-term real economic growth in the United States, why are many rural areas chronically depressed?

What changes in policy at the Federal, state and local level can be designed to increase job opportunities in rural areas? A team research approach could provide a guide for changes in policy and more effective use of rural development funds.

What are the effects on farm income and consumer prices of environmental rules that pertain to farming? What environmental benefits result from such restrictions on farmers?

What is the potential for microbial production of useful complex organic compounds including food products? Economic microbial processes for producing many complex organic chemicals from waste products appear feasible.

What are the individual and cumulative impacts of public domestic feeding programs on recipients and the Nation's economy? The annual level of current Federal programs is more than $7 billion. This research will facilitate analysis of alternative policy proposals.

How and how much is the instability of food and fiber product prices accelerating wage-price inflation and so handicapping real national economic growth? What gains in real economic growth would result from alterntive price stabilizing mechanisms? What are the distributional effects of alternative economic gains and losses?

Since the production time frame for timber is much longer than for most agricultural crops, the economic consequences from trade policies in timber products may not be fully apparent for decades. Better economic methodologies are needed for assessing the gross national product, social welfare, and capital formation in developing countries.

Engineering, Computer and Material Sciences

Can man-machine interfaces be made so simple as to allow real time translation by untrained personnel. Such developments would not only provide improved communications between the nations, but also have a profound change in our daily life.

How can productivity be enhanced by automation and artificial intelligence? With limited trained manpower supply in some areas and the saturation of productivity in others, it is extremely important for the nation to develop methods which will permit continual increases in productivity.

Can new materials such as ceramics be developed to replace metals in high temperature situations. For example, use of ceramics in turbine blades will permit greatly increased operating temperatures, reduction of size, increase in efficiency, and reduction in fuel consumption.

The economic and predictable fracture of rock is of critical importance to energy production. Obvious examples are drilling for new resources, mining of coal, oil shale and uranium, and releasing natural gas from low permeability formations. Research is needed on the mechanical behavior of rocks, in order to improve our understanding of them as engineering materials.

Can new materials be developed which would be less dependent on critical or strategic elements? The obvious example of a benefit to be derived from research on this area is the possible substitution for Cr in steels.

Computer models of physical and socio-economic processes are needed to guide, and often to replace, experimentation. Advances in analytical and numerical techniques and in computer hardware are required to simulate these processes more effectively.

How do cracks initiate and propagate in materials? This research should provide information needed to develop structural materials that resist corrosion and failure under stress.

How can structures be designed and constructed to be both economical and earthquake resistant? In addition to reductions in life loss and personal injury, implementation of improved design procedures is expected to reduce losses to buildings alone by an average of $250 million per year.

Environmental and Ecological Sciences

Can specific bioprocessing methods be designed for removing and degrading toxic pollutants in industrial process and waste water? The benefits would be reduction of such agents to innocuous gases, production of chemical feed stock, and improvement of water quality.

What are the ultimate carrying capacities of the terrestrial biosphere?

What ecological factors and life-cycle phenomena govern insect dispersion and population explosions? Research on this question can lead to the development of innovative pest management technology to supplement current biological, cultural, and chemical control measures.

To what extent does nitrogen use in agriculture affect the ozone layer and what are the costs and environmental benefits of reduced nitrogen applications?

What is the chemical composition of precipitation and dry particulate matter and how does it vary with season and location? This information will provide baseline data for atmospheric input to nutrient cycling and can relate to both point and non-point sources of air pollution.

What factors influence susceptibility of harvested plant and animal products to post-harvest losses? In many parts of the world, such losses represent 30 to 50 percent of the food supply. Research can promote development of the technology required to preserve quality and protect against losses from rodents and insects.

How can the environmental stress tolerance of current crops and grasslands be improved? Utilization of as much as 40 percent of the world's noncultivated but potentially productive land is limited because of severe weather aberrations and other stress conditions.

General (Interdisciplinary)

To what extent can the occurrences of natural hazards such as fire, flood, earthquake, and pestilence be foreseen sufficiently in advance to permit mitigation of their effects? The problems of prediction and of mitigation are different for each hazard, but for each, research offers promise of reducing human and physical costs.

What are the economic, technical, and public health impacts of restricting antibiotics and other additives in animal feeds? Adverse impacts may more than offset direct benefits of feed additive bans.

To what extent are agricultural chemicals transmitted to the Nation's waterways and what are the most cost-effective ways of reducing this pollution?

How will geoclimatic changes from increasing carbon dioxide levels and particulate loads in the atmosphere impact agricultural productivity? Research is needed to determine the influence of such changes on temperature, rainfall and other climatic variables that could significantly influence the agricultural potential of different regions.

What factors most influence the distribution of foods and so relate to human health? Research to help answer this question is needed prior to public nutrition programs. Such research could indirectly enable reduced health costs.

What are the economic potentials for expanding food production by (a) land and water development, and (b) application of new technology? This research would show the capability of the U.S. and other countries to meet the rising world demand for food.

Can productive self-sustaining systems be developed to utilize biological wastes? Research in this area could provide a means of improving composting of organic wastes and preventing soil, water and air pollution with potential for yielding energy and other useful products.

Physics and Biophysics

Can materials be found that exhibit superconductivity at room temperature? Such a discovery would be extremely important to our energy needs as well as revolutionize all technology using electrical energy.

Are there fundamental building blocks in nature? Some recent advances have been made which indicate that even the subnuclear "particles" are not fundamental and further research is necessary to uncover the secrets of the nucleus.

How can considerations of second law efficiencies be incorporated into energy strategies? Energy should be valued not by its amount alone, but also by its thermodynamic quality. A significant reassessment of energy economics may be in order.

How are the fundamental forces of nature related? Four types are currently known: nuclear (strong), electromagnetic, radioactive (weak) and gravitational. A deep connection was recently discovered between the weak force and electromagnetism. Are the weak, the strong, and electromagnetic forces aspects of a single underlying force? Is it possible to include the gravitational force? Is there just one kind of elementary particle and one important force?

Does an "island of stability" beyond the current periodic table or "abnormal" states of nuclear matter exist? These speculations can be tested and if found could have important consequences for nuclear energy production.

What is the nature of gravity? Are there gravity waves, and if they exist, how do they propagate and at what velocity?

What is the nature of matter? Why is matter and charge quantized?

What are the limits for communications use of the channel capacity in the visible spectrum? Progress in this area could significantly expand the capacity of optical communication systems, and since these systems use glass fibers instead of copper, their use would result in tremendous monetary and resource savings.

Can microwave technology or other alternative sources of energy be safely and effectively used to process and preserve food? Food processing and preservation account for nearly 5% of the nation's consumption of fossil energy. Research could provide alternative less costly energy sources and methodology.

Mr. FUQUA. Thank you very much, Dr. Press, for a very ambitious and well-thought-out program. I think in the interest of time and to eliminate any duplication of questions it may be appropriate to hear from you now, Dr. Stever, and I think many of the questions may appropriately be asked of both of you. So welcome back again this week. You are getting to be a resident witness.

Dr. Guy Stever is chairman of the Assembly of Engineering of the National Research Council and was science adviser to President Ford.

Dr. Stever, we are happy to have you as a former director of the National Science Foundation.

STATEMENT OF DR. H. GUYFORD STEVER, CHAIRMAN, ASSEMBLY OF ENGINEERING, NATIONAL RESEARCH COUNCIL, AND FORMER SCIENCE ADVISOR TO PRESIDENT GERALD R. FORD

Dr. STEVER. It is a pleasure to be here. You know we scientists and engineers like to be quantitative about things and measure things and we finally discovered that a congressional hearing is three science advisers long. You could have selected more.

Mr. Chairman, in the interest of time, to get to your questions, I am going to follow my prepared testimony, but I will leap quite a bit.

Mr. FUQUA. All three statements, those of Dr. Keyworth, Dr. Press, and yourself, will be made part of the record in their entirety.

Dr. STEVER. Thank you. I want to join Dr. Press in those agreements that he made with Dr. Keyworth. I think these are very strong points of agreement among us, and I am very pleased that Dr. Press made them. I think the Nation's R. & D. structure is a good structure. But we are concerned with the magnitude of that structure rather than with the structure itself.

The national R. & D. system has served us well in the past, producing the innovations that were necessary to improve our health, our standard of living, and our defense. It is not a centrally planned effort, though it is carefully observed and studied both here and abroad. It results from a myriad of separate considerations and decisions by many industrial companies, large and small; by Government departments and agencies; and by Congresses and Presidential administrations. It has been hammered into shape over the decades since World War II.

Several distinguished leaders of research and development in centrally planned economies overseas have told me from time to time that we needed more centralized planning and control in our R. & D. structure, to accommodate the increasing complexity and interdependence of all the matters that R. & D. affects. With that I do not agree. I have always considered the pluralistic R. & D. program of the United States as one of our great strengths. It has enabled us to explore newly developing fields of science, to capitalize quickly on discoveries and innovations, and to bring new ideas into the market. It uses the initiatives and strengths of many, many minds approaching problems from different points of view, taking from those minds the best that they have to offer. Individual initia tive is not stifled as it is where control is exerted completely from the top.

On the other hand, the subject of your hearings today may pinpoint one of the weaknesses of our decentralized R. & D. program. Centrally planned economies often plan for 5- and 10-year programs, and they budget for them. A weakness of our R. & D. budgeting in the past has been that expenditures rise and fall with short-term economic and political cycles; the economic cycles control the inputs of funds from the private sector, and the political cycles control funding from Federal sources.

I don't advocate sticking to programs or narrow projects for 10-year periods if they prove ineffective. I do advocate picking important fields of science and technology and carrying through on them, shifting from project to project as necessary.

In our research and development structure, applied research and development are concentrated in private companies, which know their businesses and customers and can manage the development of successful ideas to accommodate the economics of the business world. Government actions can greatly assist industrial R. & D. by creating a climate that enables industry to make profits and to invest those profits in the applied research and development necessary to upgrade industrial processes and produce new products.

During about the last decade and a half, it has become clear that international competition in industrial markets is increasing very rapidly. In recent years we have explored this problem of competition in private and pulic forums. On the witness stand have been industrialists, investors, government administrators, members of Congress, educators, engineers, economists, lawyers, scientists, inventors, entrepreneurs, consumers, labor leaders, environmentalists, taxpayers, and stockholders. The result, in our approach to large-scale efforts such as R. & D., is a much better understanding of the issues and, at last, a renewed effort to create a financial climate favorable to innovation. This climate definitely worsened very much in the 1970's.

Tax laws now, however, are being rewritten to encourage investment in long-term gains rather than ordinary income. If such a favorable tax climate can be established, and if inflation can be beaten back—for it still remains an enormous block to long-term investment—we have a chance of tapping once again the research and development potential of the country to get the new processes and products that will make us more competitive.

Industrial leaders have already recognized that the national concentration on short-term gains, brought on partly by inflation and partly by an unfavorable investment climate, has pulled them away from a proper balance between short- and long-term gains in their capital investments. They are moving toward a better balance. Government has a big role to play here, not only in creating the tax environment but also in beating inflation. And it has another task: insuring the strengthening of university research and education, which produce the scientists and engineers who conceive innovative ideas and the economists and managers who understand the process of innovation and can recognize and apply those ideas.

Every now and then we hear criticisms of the quality of the fields of research and development supported by the Federal Government. When foreign leaders tell us what our technological strengths are, they pick aircraft, they pick pharmaceuticals and health, they pick agriculture products, and they pick computers. The first three of those have been and remain primary places for the investment of Government R. & D. funds; in the last one, computers, the government invested in the early stages and provided an immense market. So let us not say broadly that our Government R. & D. investments have been bad ones. We have to remember our past success and where we are winning at the present time.

It is my thesis that the total government support of research and development is already too low; a further reduction will constitute another blow to this important sector.

With respect to our international competition, though we once led all developed countries in the number of R. & D. scientists and engineers as a proportion of the labor force, with about 65 per 10,000 employees in 1967, this proportion dropped steadily until about 1974, when it reached a value more like 55. Since 1975 we have increased this number slightly, but it is still lower than it was in 1967.

In the Soviet Union the number of R. & D. scientists and engineers per 10,000 members of the labor force was well below the U.S. value in 1967 but has climbed steadily since. Some estimates place the current value of this index in the Soviet Union at about 80, which is well above the U.S. level. Soviet colleagues will say that that is a little high, but they still admit that they have more science and technology workers, R. & D. workers than in the United States.

The numbers for West Germany and Japan have also climbed steadily and are approaching our level. If one subtracted the numbers of scientists and engineers involved in military R. & D., of which Japan and West Germany do very little, one would find that both have more scientists and engineers per 10,000 members of the labor force than we do.

The funding of our national R. & D. effort has been shared over the years by the non-Federal sector—mainly industry—and the Federal Government. Ever since 1967, some—and I am among them—have shown a strong desire to reduce the Federal R. & D. funding load and increase the non-Federal load. That in fact has steadily occurred. In 1967 industry supported less than 40 percent of all R. & D. in the country, and the Federal Government supported about 60 percent.

Today, as a result of steady change over the intervening 14 years, the Federal Government, provides 47 percent of the Nation's R. & D. funding, with 49 percent coming from industry. If reducing the Federal responsibility in this area is our objective, we are accomplishing it.

However, anyone who thinks that such a change can be accomplished rapidly does not understand the dynamics of the research and development system. It takes institutions like industry a long time to build greater strength in research and development by adding facilities, equipment, and personnel. It takes universities a long time to produce scientists and engineers to do the research and development. It takes funding agencies a long time to adjust as well. Personally, I am in favor of increasing the percentage of R. &

D. funding from private sources. But I believe that trend must be a slow, steady trend, as it has been over the past 14 years.

In summary, I think that over the past decade and a half we have neglected our research and development in comparison with our commercial competitors and our military adversaries. I think also that we have failed to establish the necessary climate for innovation in using the results of research and development, with a consequent reduction in the numbers of innovations the United States has produced compared to the rest of the world. Frankly, I think now we should be talking not about weakening our R. & D. resources, but rather about some long-term plans to insure their stable and strong support.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Stever follows:]

STATEMENT OF DR. H. GUYFORD STEVER, CHAIRMAN, ASSEMBLY OF ENGINEERING, NATIONAL RESEARH COUNCIL

Mr. Chairman, members of the committee: Thank you for the opportunity to testify today on "U.S. Science and Technology under Budget Stress."

It is generally recognized throughout the world that national health, economic well-being, and defense depend strongly on science and technology. Starting from a good base following World War II, the United States has built a strong research and development program with many competent people working in well-equipped institutions on projects aimed at meeting the broad spectrum of our nation's needs. That program has been the envy of other countries, both developed and developing, and has served as a model for many national research and development programs. This effort has long been considered one of our American strong points in ensuring both economic progress and defense.

Before commenting on the impact of budget stress on this program, let me give a 1981 snapshot of that research and development program. R&D in this country is a big business: almost $70 billion this year. The United States spends almost one-third of the world's R&D funds. About 47 percent of these funds come from the federal government, and 49 percent from industry; universities and nonprofit organizations--mostly foundations--supply 2 percent each.

Private industry is overwhelmingly the nation's biggest performer of R&D, using its own funds and half of the government's R&D funds; government laboratories spend only 13 percent of the total, practically all from government sources. Universities spend 9 percent of the funds, again mainly from the government; that 9 percent includes 3 percent for the federally funded research and development centers (FFRDC's) administered by the

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universities for the government (laboratories such as Los Alamos of the University of California, working in nuclear weapons; the Jet Propulsion Laboratory of California Institute of Technology, working in space flight; and Draper Laboratories of MIT, working in guidance and control). Nonprofit laboratories, such as the Stanford Research Institute, perform 3 percent of the work.

The character of our work is divided among basic research, applied research, and development in portions of 13, 22, and 65 percent, respectively. While there are no formulas for determining the proper balance among these three categories of R&D, our balance appears about right considering the average amounts of the three categories that go into all innovations, large and small. (Of course, from innovation to innovation there is great variation in the percentages, but this is a good average.)

About one-quarter of the nation's 2.8 million scientists and engineers are employed in research and development. Those 670,000 R&D scientists and engineers are divided among government (10 percent); industry (71 percent); universities, including the FFRDC's (12 percent); and nonprofits (4 percent).

Those, then are the dimensions of the nation's R&D structure. I think it is a good structure. It has served us well in the past, producing the innovations that were necessary to improve our health, our standard of living, and our defense. It is not a centrally planned effort, though it is carefully observed and studied both here and abroad. It results from a myriad of seperate considerations and decisions by many industrial companies, large and small, by government departments and agencies, and by congresses and

Presidential administrations. It has been hammered into shape over the decades since World War II.

Several distinguished leaders of research and development in centrally planned economies overseas have told me from time to time that we needed more centralized planning and control in our R&D structure, to accommodate the increasing complexity and interdependence of all the matters that R&D affects. With that I do not agree. I have always considered the pluralistic R&D program of the United States as one of our great strengths. I still do. It has enabled us to explore newly developing fields of science, to capitalize quickly on discoveries and innovations, and to bring new ideas into the market place. It uses the initiative and strength of many, many minds approaching our problems from different points of view, taking from those minds the best that they have to offer. Individual initiative is not stifled as it is where control is exerted from the top.

On the other hand, the subject of your hearings today may pinpoint one of the weaknesses of our decentralized R&D program. Centrally planned economies often plan for five and ten year programs, and they budget for them. A weakness of our R&D budgeting in the past has been that expenditures rise and fall with short-term economic and political cycles; the economic cycles control the inputs of funds from the private sector, and the political cycles control funding from federal sources.

Most basic research in the physical, biological, and medical sciences is performed in universities. As one consequence, we turn out graduates who have been steeped in creative thinking. That is a very important advantage of our structure, for graduates in science and engineering who have not been exposed to the atmosphere of university research miss something very important in their education. Our university research is high in quality; U.S. citizens have received about half the Nobel prizes in science since 1930. In the universities, we have performed the fundamental scientific research underlying the solid state in computers, nuclear power, genetic engineering, antibiotics, scientific instruments, and many other big business fields of today.

Receiving most of their research funds from federal sources, the universities are the most sensitive of our R&D structure's elements to changes in federal funding, both long-term and short-term. There is a long-term effect that has been cumulative in the universities; in earlier days (two or three decades ago), universities in the United States were the envy of universities elsewhere in the world. Their equipment and facilities could bear comparison with those of any institution involved in R&D. Today university laboratories and equipment are in many cases obsolescent, due to a long-term decline, beginning in about 1971, in the number of real dollars put into research and development by the federal government; though this trend was reversed in 1975, the increase has brought funding only back to about the 1971 level, and most of that has been used for program expenses rather than equipment and facilities. Today, our universities are not well equipped or well supplied with facilities to do the research jobs before them.

Any proposed short-term drop in funds for university research will add to the effects of the long-term drop, and programs will suffer. Already universities are finding it difficult to attract and retain talented young professors, whose salaries are lower, and whose research opportunities are narrower, than they would be in industry. This shortage of funds spills over to students; they have more difficulty getting thesis research support, graduate fellowships, and scholarships. They also sense the lowering of morale in university research, and they are quick to read signs that they may be entering fields where opportunities are not as great as they once were.

There is another influence of changing funding levels for universities. Our system has developed a weakness over recent decades as a result of the increasing proportion of federal funds in research support for universities and the corresponding decline in industrial funding of university research. This concentration of funding in the federal government has focused research in the universities on government missions--defense, health, weather, climate, space, and so on--and away from those sciences and technologies that help industry develop their manufacturing processes and the technology for efficient production. It has also lessened the interest of graduates in going into industry from the universities to work on the innovations needed for an expanding and competitive economy. This shift of emphasis in universities, away from industrial needs and toward those of government, has been noted; in recent years there have been many attempts to counter the shift, including industry efforts to get closer to the universities and support more research and federal programs to put some government R&D funds into strengthening university-industry ties. Many of these attempts will be affected by the short-term tightening of federal research funding.

In our research and development structure, applied research and development are concentrated in private companies, which know their businesses and customers and can manage the development of successful ideas, so as to accommodate the economics of the business world. Government actions greatly affect industrial R&D programs, by creating a climate that enables industry to make profits and to invest those profits in the applied research and development necessary to upgrade industrial processes and produce new products.

On this subject, Senator Lloyd Bentsen, Democrat from Texas, who recently served as chairman of the Joint Economic Committee of the Congress, has summed up the importance of innovation in a paper entitled, "Taxation, Research and Development." He writes, "Today's investment in research and innovation will help forge tomorrow's economic and social course. Industrial innovation is at the core of the economic well-being of the United States and is a major contributor to economic growth. Innovation influences inflation and stimulates productivity, employment and the ability of U.S. products to compete in domestic and world markets." He goes on to say, "Through investment, inventive individuals--working independently or for a company--obtain the financial backing which enables them to pursue their research and development. Investment provides the facilities not only for the actual research work, but also for the plants and tools to transform the innovative ideas into a marketable product. And it is investment through education which equips individuals with the knowledge and skill to engage in R&D work."

During about the last decade and a half, it has become increasingly clear that international competition in industrial markets is increasing very rapidly. Some of the effects are very clear: our marketplaces are filled with foreign-made products, some of our most basic industries have been devastated or badly damaged in both domestic and foreign markets, and jobs are going overseas. In the case of our competition with Japan, change crept up on us gradually. First came the production of simple radio and television circuits; then, in shipbuilding and iron and steel manufacturing, the cry became "cheap labor." When Japanese scientific instruments, cameras, and machine tools began to make their marks in the world, we noticed something more than just cheap labor. When Japan began to take the lead in the automotive field, we realized that they had a very well worked out total business system. Now they are challenging us in the highest technology fields of computers and communications. For example, I am told that if the contract for AT&T's northeast corridor optical fiber system had gone to the lowest bidder, it would have gone to a Japanese consortium.

In recent years, in private and public forums, we have explored this problem of competition. On the witness stand have been industrialists, investors, government administrators, members of Congress, educators, engineers, economists, lawyers, scientists, inventors, entrepreneurs, consumers, labor leaders, envirnmentalists, taxpayers, and stockholders. The result is a much better understanding of the issues, and, at last, a renewed effort to create a financial climate favorable to innovation. This climate definitely worsened very much in the 1970's. Tax laws now, however, are being rewritten to encourage investment in long-term gains rather than ordinary income. If such a favorable tax climate can be established, and if inflation can be beaten back--for it still remains an enormous block to long-term investment--we have a chance of tapping once again the research and development potential of the country to get the new processes and products that will make us more competitive again.

Industrial leaders have already recognized that the national concentration on short-term gains, brought on partly by inflation and partly by an unfavorable investment climate, has pulled them away from a proper balance between short- and long-term gains in their capital investments. They are moving toward a better balance. Government has a big role to play here, not only in creating the tax environment but also in beating inflation. And it has another role, which is to ensure the strengthening of university research and education, which produces the scientists and engineers who conceive innovative ideas and the economists and managers who understand the innovative process of innovation and can recognize and apply those ideas.

In our R&D structure, government laboratories concentrate primarily on fields for which the federal government has direct responsibility--weaponry, climate and weather, oceanography, and so on. However, in one such field, space, there is a very large "spinoff" of industrial products and processes, for NASA's research often leads to innovation. Similar effects can be seen in two other areas where government has assumed the primary responsibility for basic and applied research, namely health and agriculture. Pharmaceutical companies and others in the health field have benefitted from federally sponsored biomedical research, and our food industries have also depended heavily on government-sponsored research.

It is my thesis that the total government support of research and development is already too low; a further reduction of it is going to constitute another blow to this important sector. With respect to our international competition, though we led all developed countries in the number of R&D scientists and engineers as a proportion of the labor force, with about

65 per 10,000 employees in 1967, this proportion dropped steadily until about 1974, when it reached a value more like 55. Since 1975 we have increased this number slightly, but it is still lower than it was in 1967. In the Soviet Union the number of R&D scientists and engineers per 10,000 members of the labor force was well below the U.S. value in 1967 but has climbed steadily since. Some estimates place the current value of this index in the Soviet Union at about 80, which is well above the U.S. level. The numbers for West Germany and Japan have also climbed steadily and are approaching our level. If one subtracted the numbers of scientists and engineers involved in military R&D, of which Japan and West Germany do very little, one would find that both have more scientists and engineers per 10,000 members of the labor force than we do.

There is simply no question that for the last decade and a half we have not paid enough attention to the total magnitude of R&D funding in this country. And if one superimposes on that trend the short-term cutback now proposed, one finds only a worsening situation.

The funding of our national R&D effort has been shared over the years by the nonfederal sector (mainly industry) and the federal government. Ever since 1967, some have shown a strong desire to reduce the federal R&D funding load and increase the nonfederal load. That in fact has steadily occurred. In 1967 industry supported less than 40 percent of all R&D in the country, and the federal government supported about 60 percent. Today, as a result of steady change over the intervening fourteen years, the federal government, as I said earlier, provides 47 percent of the nation's R&D funding, with 49 percent coming from industry. So if reducing the federal responsibility in this area is our objective, we are accomplishing it. However, anyone who thinks that such a change can be accomplished rapidly does not understand the dynamics of the research and development system. It takes institutions like industry a long time to build greater strength in research and development by adding facilities, equipment, and personnel. It takes universities a long time to produce scientists and engineers to do the research and development. It takes funding agencies a long time to adjust as well. Personally, I am in favor of increasing the percentage of R&D funding from private sources. But I believe that trend must be a slow, steady trend, as it has been over the past fourteen years.

In sumary, I think we have had a decade and a half in which we have neglected our research and development in comparison with our competitors. I think also that we have failed to establish the necessary climate for innovation in using the results of research and development, with a consequent reduction in the numbers of innovations the United States has produced compared to the rest of the world. Frankly, I think now we should be talking not about weakening our R&D resources, but rather about some long-term plans to ensure their stable and strong support.

Mr. **Fuqua**. Thank you very much, Dr. Stever, for a very excellent statement. Dr. Press, if you would rejoin us. We will start the questioning with the members who were not able to question Dr. Keyworth, and we will begin with Mr. Ertel.

Mr. **Ertel**. Thank you, Mr. Chairman.

Gentlemen, the science adviser for the present President, Dr. Keyworth, has indicated that we need to increase the quality of instrumentation in the research laboratories of the United States, specifically in the universities. To show how he equates increased instrumentation in those laboratories with an economic recovery package, he believes that somehow we are going to get greater donations to these universities for instrumentation by the private sector.

I don't share that view. Maybe we will get some increase, but I don't think it is going to serve the entire purpose. And many of the grants you get from industry have strings tied to them, that they want experimentation done in specific research areas, which leaves other areas without funding. I would like to know your views on whether or not the approach of just giving tax incentives to industry to help in the instrumentation of our laboratories, is sufficient, If it isn't sufficient, how do we go about increasing and improving instrumentation in our university laboratories, which seems to be an estimated cost of $1 to $2 billion, and the administration has zeroed that out in the Federal budget?

Dr. **Press**. I think industry is to be commended for what it has done in recent years and for its plans to increase contributions to university research including equipment, fellowships and direct grants. Recent tax changes may help, although there is some uncertainty there. But the trend is in the right direction.

However, industrial leaders themselves caution that they could not possibly replace any reductions by the Federal Government or make up any deficits that have accumulated over the years in an area such as instrumentation. As one industry leader said at our October conference, even if industrial contributions to universities tripled over the rest of this decade, that would be equivalent to only 1 year's proposed budget cut on the part of the Government. The atmosphere is good in terms of industry's recognition of new opportunities in working with universities, the recognition of its obligation to maintain the scientific and technological base and to improve scientific and engineering manpower training, but we have to be careful not to overestimate the potential. So I agree with the thrust of your question, that an important Federal initiative to improve equipment, and research equipment facilities at universities is still very much needed.

Dr. **Stever**. I agree. Mr. Fuqua sponsored a hearing a year or two ago on Government help in improving industry-university cooperation, and several industry people, who in fact had started to increase their cooperation, said that when they started joint projects with academic laboratories they were astounded. The first thing they had to do was to bring them up somewhere close to the industry in their instrumentation. I think in the last few years industry has had a shocking awakening, the fact that our universities have fallen down very badly in instrumentation.

Mr. **Ertel**. Thank you. I have one other question. It occurred to me while Dr. Keyworth was testifying, he was talking about the problems with faculties in universities as well and the fact that they are not growing and hiring a new young faculty member becomes nearly impossible, specifically in the scientific areas.

He made this statement. The Federal Government is unlikely to intervene in this process even though it has a stake in the continuing health of university research and associated education.

Recently I listened to Lester Therow, who is an economist. He was talking about the scientific endeavor in the United States. His theory is that the scientific people, both in the universities and in secondary education, even just math teachers, are getting such great offers from industry because there is a dearth of people who are qualified, that we are losing the educational backup to train other people.

His theory is that we are going to be losing the future for science education and training new scientists. Then he says with the increasing Federal budget for defense, because our defense industry is so technologically oriented, that there is going to be even more of a drain on scientific personnel. The bidding for salaries will bring people into the defense establishment, especially into defense-related technological industries and research and development.

So that the strain in the immediate future will be even more acute as far as either training new personnel or in fact having the people to train them, because there is going to be a drain. Also, the people that remain in education will be even more expensive, because they are going to be demanding higher salaries.

No. 1, is he right? And No. 2, if he is right, how do we combat that problem? Because if he is right, we are going to be facing a real crisis in the 1990's and 2000's for scientific personnel in the educational field.

Dr. **Stever**. I would like to start and make some comments on that. First of all, we are in a free enterprise system, and there is no question that the phenomenon of more attractive salaries in industry has affected hiring in academic institutions. Industrial people recognize this, too, and a number of their efforts at increasing their cooperation with universities are aimed at precisely this problem. One proposal, for example, is that a young promising teacher could be offered graduate opportunities, with the fees paid by a corporation as a loan, and that such a loan could be excused over a period of years that the individual later spends in the university teaching.

There are many other schemes—joint appointments and the like—but I do not think that those are going to solve the problem completely, and I do not think it is only competition for personnel in the defense industries. Competition in the electronics business and a number of other commercial businesses is so great that you are going to see that drain on universities continue. Something has to be done.

Mr. **Ertel**. The answer to the last question that you phrased to me, that is the whole question.

Dr. **Stever**. You know, if we are going to use the Federal Government, which does tend to display a 1-year funding cycle, it might be good to start thinking of it as a gap filler in these problem areas. The universities are clearly such on area. They need a scheme to raise salaries and to update their research equipment.

Being in a university has some advantages for a scientist. He can pick his own field of research, for example. He has in many privileges for being there, and lots of people would like to be there if it weren't just awful in pay and research environment. Maybe we should use our Government funding by pointing it a little in that direction.

Mr. **Fuqua**. Mr. Brown?

Mr. **Brown**. Thank you, Mr. Chairman.

May I ask unanimous consent to insert an opening statement?

Mr. **Fuqua**. Yes, without objection.

[The prepared statement of Mr. Brown appears on pp 3-4:]

Mr. **Brown**. Gentlemen, this is an issue I wish to bring up that you haven't touched on specifically, but I note that within the last few days the other body, the Senate, has passed a measure aimed at stimulating the health of research and development in this country in the form of legislation to earmark a certain percentage of the Federal R. & D. budget, which would be directed to small business enterprises. I understand that has passed the Senate with minimum objection, and according to one of the press reports that I saw, the cost of this is not large, but it is projected to run from $3 to $20 million a year over the next 2 or 3 years.

Now, at the same time, expenditures are down for a number of other initiatives aimed at stimulating small R. & D. business and

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enhancing cooperation between business and industry—for example, provisions of the Stevenson-Wydler Act have been, as we say now, zero funded or zeroed out. Can we assume that this represents a coherent philosophy on the part of the administration, which is supporting this new initiative to sort of let the lesser quality programs wither away and that this small business R & D. set aside is a high quality program that Dr. Keyworth referred to? Would you concur in that sort of an analysis?

Dr. **Press**. By and large I am not sure that set asides with fixed percentages where you must spend the money in a certain way are the most productive and efficient means of conducting scientific research. On the other hand, the program in support of small industry at the NSF is a good program. It seems to be working. It is reviewed, and the budget grows or doesn't depending upon the quality of the program. So the notion that more Federal spending for research in small enterprises should be followed is a good one, but I think formulae requiring expenditures of a certain fixed amount each year would lead to programs that are not properly evaluated and may not be terribly efficient.

If we could disseminate the NSF model through other agencies and have growth determined by program quality, that would be the best way to capitalize on the enormous potential of small businesses.

Dr. **Stever**. I agree with what Frank Press has said. In the area of small business, where innovative new products and research are going to pay off, you in Congress should emphasize providing a good climate for private investment. Private investment people have a very good sense about what is going to succeed and what isn't. Not a perfect sense, however, and I think the Federal Government should maintain some role, but I don't think the Federal Government is a good selector of the ones that are going to succeed. I think you have a different weapon in your arsenal to emphasize, although I think some effort by Government is good, but not the sole effort.

Mr. **Brown**. I am sure that both of you will remember, Dr. Press particularly, that when the previous administration announced its initiatives dealing with innovation and productivity, they were subjected to considerable criticism for lacking this component of tax incentive that you are referring to as an overall part of the program to stimulate innovation and productivity, small business innovation and productivity, in general.

Dr. **Stever**. I don't think that was Dr. Press' fault, however.

Mr. **Brown**. I wasn't implying that. I am pointing out that he would be familiar with the fact that there was that lack of emphasis. The question I am raising now is whether the new thrust, which calls for a new expenditure program, can be properly categorized as a high quality, carefully targeted approach aimed at replacing the failed initiatives of past years, and I think that you have attempted to respond to that.

That is all, Mr. Chairman.

Mr. **Fuqua**. Mr. Shamansky?

Mr. **Shamansky**. Thank you, Mr. Chairman.

Recently I read an article on the Op. Ed. page of the New York Times, a thesis comparing the Japanese direction of investment in research and development through their Ministry of International Trade and Industry, called MITI, and comparing that with our Federal expenditures, which greatly concentrate on the Department of Defense and the attitudes that the Department of Defense takes toward its research and development and the subsequent utilization. I would like you to comment on the two if you are familiar with it at all and are we really getting our money's worth with the mode that we are using for Federal R. & D.?

In other words, with such a great concentration on the military, is that our best vehicle for so much of our research and development?

Dr. **STEVER**. Let's never sell short the Department of Defense's fine support for research and development. However, there is no question that they have had more success in their areas than we have in some nondefense areas. You talk about the Japanese competition. The Japanese did not in the beginning win economically on the basis of great research. They used other people's research. They went on good management practices, quality, teamwork, care, dozens of things. Now they are changing, and you will discover that the Japanese, in the economic competition, are beginning to win on the basis of high technology and science. I don't think one should be lulled by statements that say Japan is now beginning to ask questions about how they can become R. & D. leaders in the world. They are R. & D. leaders in the world.

Mr. **SHAMANSKY**. But my question then is, Are we wrong in pursuing, in discussing the great amount of Federal R. & D. when we are just following the same old pattern of R. & D.?

Dr. **STEVER**. We aren't quite. Don't forget that the Federal Government in the last decade and a half has reduced its emphasis on military R. & D. pretty steadily. It has gone down to about 50 percent, whereas it was 70 percent a decade and a half ago. Our real problem is that with the Soviet Union and other potential adversaries we tend to be competing in the military field, and we have to match their strengths. In the commerical field we tend to be competing with West Germany and Japan and other nations that emphasize commercial competition. So we are competing with teams that specialize.

Mr. **SHAMANSKY**. Dr. Stever, your comments lead me to my second question. I made notes during your presentation, and referring to page 8 of your testimony, talking about the climate that we have here, and you show a marvelous faith, it seems to me, in the ability of our scientists and engineers to conceive innovative ideas and the economists and managers who understand the process and can apply those ideas. It seems to me that you describe where our economists and managers apparently haven't done the very thing you say that they have here.

In other words, what good does it do us to have greater productivity if we don't know what it is we are producing?

Dr. **STEVER**. I think we have made mistakes in the past, but at last we are getting alert. For a long time this country paid no attention to inflation, which has been one of the biggest blocks to industrial support of long-term projects. This country hardly knew about inflation until the mid-1970's and didn't do anything about it. When I was science adviser, the OMB never permitted us to use inflation factors when we put together our budgets. About 5 years ago the Government finally awakened to the fact that R. & D. was affected by inflation.

I think there is a mood in this country that encourage people to take the short-term approach, seeking payoffs over extremely short periods. This tendency has unbalanced us, and we are being overtaken by competitors who have longer term approaches. So I have faith in our system. I have faith in the actions of Congress in this matter. In recent years, Congress has made efforts to analyze the details and dynamics of this international competition and has concluded that we have constructed—not by intent, but by default—a bad climate for industrial innovation. Now Congress is trying to correct it. I think this is a great triumph of our system, and I hope we stick to that course long enough to make a difference.

Mr. **Fuqua**. Mrs. Bouquard?

Mrs. **Bouquard**. I ask that my opening statement be placed in the record.

Mr. **Fuqua**. Without objections it will be placed in the record.

[The prepared statement of Mrs. Bouquard follows:]

STATEMENT OF HON. MARILYN L. BOUQUARD

This is a most curious time; we are being told new things about the federal role in science and technology that even raise questions about decades of successful federal cooperation with industry and universities. In the area of energy policy we are told there should be no federal R&D support of fossil, solar or conservation energy technologies. The federal support of nuclear fission R&D is now dropping dramatically despite all the Administration's rhetoric to the contrary about saving the nuclear option. In other civilian R&D the federal government is pulling out of proven partnerships with industry which are so important to U.S. preeminence such as in aviation which has been a vital element or our international trade balance.

I chaired a Subcommittee hearing just this week on the issue of electric energy systems and storage where the Administration is simply telling us there is no federal role in developing technology to transmit or store energy.

This morning I am curious as to whether present and past Science Advisors feel that their job involves a determination of the federal role in technology development. If so, I am curious as to where the present science advisor has been while the fossil energy R&D was being put on a "going out of business" curve and other energy technologies, including nuclear, were being severely reduced. Finally, I am curious as to where all three gentlemen would stand on the issue of funding and emphasis for magnetic fusion where the present Administration seems to be interested in returning the program to a basic research phase.

I want to congratulate Chairman Fuqua for having this first in a series of hearings on budget stress. I can assure him that these trends in funding for technology development are causing me extreme pain. Perhaps, the witnesses can relieve my concern somewhat with some frank answers.

Mrs. **Bouquard**. Looking over your prepared statement, Dr. Press, I notice the fact that you don't mention the phrases "technology development" or "applied research" or the "D" in "R. & D." I was wondering if the academy has interest in the Federal role of applied R. & D. through its affiliation with the National Academy of Engineering. To be more specific, is there really any concern about the Federal Government getting out of R. & D. in such areas as aeronautics or fossil and solar energy? I notice this aspect was not mentioned in your recommendations.

Mr. **Press**. I think the Federal role in development is mixed. In the areas of space and defense the Government is the sole customer. In certain civil technologies which are extremely expensive, risky and yet nationally important, like fusion energy or breeder reactors, which we may need in the next century, private industry would tend to underinvest and one might justify a Federal role.

Other areas, where one should ask the private sector to undertake development rather than the Government, are those characterized by a more near-term market orientation. The private sector might be better in judging the market and the timeliness of certain new technologies.

Certain developmental technologies that are appropriate for the Federal Government; other Federal developmental projects I believe, should be a responsibility of the private sector and the funds thereby released used in support of the longer term riskier projects or for basic research.

Mrs. **Bouquard**. What do you believe the thrust of the magnetic fusion program should be?

Dr. **Press**. I think fusion is an appropriate Federal developmental effort and could be an extremely significant source of energy in the next century. It requires a great deal of science and engineering to achieve. Industry will not make the necessary investments. We are in a critical energy position and I think development of fusion is worthy of Federal support.

Mrs. **Bouquard**. I noticed that in the 1983 request by the administration, magnetic fusion is going to be 50 million real dollars below our 1981 appropriation. What do you think the effect of this is going to be?

Dr. **Press**. I haven't seen the 1983 budget in this area so I just can't say. Within the whole fusion program there might be some more promising approaches where you might say this is a high priority approach, there is more chance that it will work, we are closer to a conclusion or break-even point, let's push our funds into magnetic fusion rather than laser fusion. I am not recommending this, but the overall notion of supporting fusion research is one that I accept.

Mrs. **Bouquard**. Thank you very much, Dr. Press.

Dr. Stever, we are happy to have you gentlemen with us today. You are apparently quite concerned about the health of Federal technology development and applied research as well as basic science. What do you understand to be the basis for having the Federal Government withdraw from these traditional roles such as NASA has played in aeronautics and DOE and ERDA and the Department of Interior have played in our coal R. & D. programs? Do you really believe that industry is going to pick up this support?

Dr. **Stever**. I would like to build on Dr. Press' statement here. There are certain areas in which the Federal Government has played the major role in supplying funds and in which I don't think industry can take over this responsibility. For example, I don't think, that NASA's aeronautical role could be quickly picked up by industry. The life-and-death struggle of aeronautical companies around the world requires tremendous investments in big facilities. NASA has those facilities; it has used them wonderfully and in cooperation with industry for a long time, in a perfect example of the good kind of industry-Government cooperation. Mr. Glickman had a session here 2 days ago in which several of us appeared along with a panel of top industry leaders in R. & D., and all supported NASA's aeronautical role.

So I think, as Dr. Press has said, we have got to look at each area separately. I don't think in this complex matter we can make general statements and say they apply across the board. We have to look carefully at each area and make the judgments accordingly.

Mrs. **Bouquard**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Flippo?

Mr. **Flippo**. On page 11, Dr. Press, you quote Lyndon Johnson and include in that quote, "Johnson speaks of finding excellence and growing creative centers of excellence in every part of the Nation."

You seem to be saying that that is a policy that we have followed since the mid-1960's. Is it your current position that we are following a policy of finding excellence and growing creative centers of excellence in every part of the Nation?

Further, you seem to be opposed to geographic distributions of these R. & D. dollars, and I wonder if you would care to comment on that. I mean, does centers of excellence preclude a geographic distribution?

Dr. **Press**. During times of budgetary growth as we had under the Johnson administration I think it was appropriate to build a national network in R. & D. capability which included supporting the best institutions and building new ones in those parts of the country where local communities wanted to make the investment with the help of the Federal Government. So at that period in our history I thought it was the right thing to do.

If we are facing major budget cuts in the Federal R. & D. budget in the next few years I think we have to assign the highest priority to those institutions which are most efficient, which have the best record in producing scientific discoveries and applications, which do the best work.

I think that we should have two programs, one which recognizes the best efforts of each region of the country as well as a national competition for the best institutions, wherever they are. That, I think, meets the needs that you have in mind.

Mr. **Flippo**. It seems to me that the concentration of the Federal R. & D. dollar at the present time may be too narrowly defined rather than being too widely dispersed. It also appears that a case might be made for a connection between the economic development of an area and the location of what might be called an elite research facility. I think there is probably some relationship.

Since that relationship may be argued to some degree, I don't see why the citizens of all geographic regions of the Nation should not participate in that, such as the great States of Florida, Tennessee, Illinois, Alabama, and other areas.

I believe on page 19 you are suggesting that government and the scientific community get together and find a way of transferring funds from the less productive areas or institutions to more productive ones.

I wonder who would define that productivity and I wonder if you would care to comment on the marginal productivity of a Federal research dollar at some of the schools such as MIT and Harvard versus a less elitist university area. Would you have any comments on such productivity?

Dr. Press. Let me again remind you what my preferred policy would be. I would like to see a national competition to find the best institutions wherever they are and commission research that could be evaluated in any way that you design as long as we pick the best places. But because I also recognize the connection between R. & D. and regional economic development I would like to have at the same time a program of recognizing the best regional institutions in the country and supporting them as well.

That part of my testimony that you referred to described a situation which is currently very serious. We are facing several years of budget constraints. I think we must get through that period preserving the best of the Nation's scientific enterprises wherever we find them.

Mr. Flippo. But according to your testimony scientific R. & D. dollars have not been growing since then and we have been following this policy.

Dr. Stever, you speak on pages 2 and 3 about decentralization, about those in Japan and others who have told to you that what we need in this country is more decentralization. You seem to be rejecting that.

Do you agree with Dr. Press or is your testimony in opposition? Do you want more decentralization of the Federal R. & D. dollar?

Dr. Stever. I want decentralization in the selection of the areas of research and development that are important. I would not necessarily decentralize the R. & D. effort by geographic area. I am in favor of decentralizing with respect to where talent is; I think I agree with Dr. Press in this respect. And I think that, in lean times, distributing our research and development funds on the basis of geographic area or population distribution will cause us to misuse some of them. In good times, we can work on that.

You talked about the people of the country who should be entitled to be a part of it. If you are talking about strengthening the educational institutions I would like to see that decentralized. I think many good minds per capita come out of every State of the Union, and we ought to make sure we are using them. In their educational years I think we have to strengthen them. If you are talking about return on the research investment, the quality, the size, and past record of research institutions should be the determining considerations.

Mr. Flippo. I don't advocate allocating the funds purely on a geographical basis, but I would like to see the part that geography plays considered and that has been a debate that has gone on in this committee for a long time and will probably continue.

Mr. Fuqua. For as long as I can remember.

Mr. Walgren?

Mr. Walgren. Thank you, Mr. Chairman.

I wonder, as perhaps a relatively partisan person, whether we are saying the right things in living with this cutback. We seem to be now opening areas about how you are going to allocate these dollars among the most efficient innovator or the most efficient researcher. And I remember Mr. Weber saying earlier this morning that he felt that there would be little support for cutbacks beyond what has already been done in certain areas.

What troubles me is whether or not the science community is saying to the Congress and the public that there should not be these cutbacks or are we saying, well, if we are going to have these cutbacks then we will allocate them between the most efficient universities and then we will get into a big fight about who is the better university.

Do you feel that it is time for the science community to say very strongly and very clearly to the public that any reduction in Federal research does a great disservice to the national interest?

Dr. PRESS. I think the determination whether this country undergoes a high technology industrial revolution depends upon a strong scientific and technical base. Not to have the vision to make the necessary investments to compete successfully in this important period in our history, I think is shortsighted and reflects irresponsible leadership.

Yes, we should tackle problems of waste and inefficiency. But to underinvest in this nation's science and technical base, people, facilities, and projects, I think is a serious mistake.

Dr. STEVER. I endorse that 100 percent.

Mr. WALGREN. I remember some comments from the debate on the NSF budget on the House floor and admittedly we talk in perhaps sometimes nonsubstantive levels but one side got up and said let's show the economic community that we are going to cut Government spending and get back to investment in our society and so let's reduce this National Science Foundation budget and it will be good for investment. Then the other side gets up and says let's show the financial community in this country that we are going to increase investment in this country and let's keep these moneys in the National Science Foundation and obviously these are investment moneys that should be spent.

What troubles me is I hear so much of the society saying we certainly support the President and we go along with the President's program and yet many of the opinion formers in the country don't walk right up to the hard question and say he is just plain wrong in this instance.

I certainly hope that the scientific community, if it believes that these investments are necessary, will say that he is just plain wrong in this instance and that that wrong creates very grave danger for our society as a whole.

Now, that is a partisan comment. Along that line I wanted to ask whether or not we could accurately measure the decline in the investment in R. & D.

The NSF budget has been held constant and then the real dollars go down. If there is any specific measurement of that decline that you folks feel could be made, I certainly would appreciate it for the record.

Then I wanted to ask also whether or not we are making an adequate transition from pure science to applied science, if that is the right word. Someone said to me one time that Britain is an example of a road that we don't want to go down in that they have very good pure science but very little translation of that science into their industrial base. It was said that the people that were involved in industry oftentimes did not have enough good scientific knowledge to solve problems well and that in the university levels in

Britain, the way that particular society has developed, the good scientists tended to stay within the universities.

Do we have a good effort to get that transition made and in your view is this an area that we should make a special effort at this point?

Dr. **Press**. Since we are running out of time, let me respond briefly. Dr. Stever wants to comment as well.

I think we in this country know as well as anybody the process for translating a new scientific idea from discovery to application to the final product, but in the past we didn't have the favorable economic climate that Japan, for instance, has had over the past decade; for that evolution. We need a regulatory policy, a relationship between Government and industry that is not adversarial. The knowhow exists in this country today, though.

Dr. **Stever**. That was going to be my remark, too.

Mr. **Walgren**. Thank you very much.

Mr. **Fuqua**. Thank you, Mr. Walgren.

One of the things that really disturbs me, and I think maybe Dr. Stever mentioned it, is the impact of across-the-board cuts when every agency and every program is treated the same, which implies from the outset that all things are equal, and it disturbs me greatly when we have across-the-board cuts, and I have been guilty of it myself. It is an easy way for bean counters to say they are treating everybody the same but it concerns me greatly when we find ourselves having to implement across-the-board cuts in valuable programs that have much higher priorities than others. In times when we are trying to choose priorities, what we should fund and what we should not, I think both of you have alluded that this totally negates any possibility of prioritizing those programs that we feel are more important than others. Maybe you would care to comment on that?

Dr. **Stever**. I certainly agree that in tight times we have to set priorities in the selection of institutions and projects. I make that remark in the context of the more general point that in the long run this country has to strengthen its R. & D. if it is going to be competitive.

However, I was pleased that Dr. Keyworth did identify some of his priorities. Whether or not they are exactly the right ones, as long as we get in the mood to emphasize the best projects, institutions, and individuals, I think we are in the right mood. Then we have got to argue about which is the best, and that should go on all the time.

Dr. **Press**. It is much more pleasurable to have Dr. Keyworth's job at a time of growing budgets when one can be particularly creative. He is facing a few years of constricting budgets and he has the courage to ask important questions: How can we better spend those dollars, what is most important; what are the less productive institutions? I admire him for facing up to those very difficult questions.

The things that concerns me, are some of the preliminary budget estimates that OMB has signed off on, particularly in energy development, in such areas as fossil, solar, and conservation, where all of those budgets, including fusion and fission are down almost $1.5 billion from fiscal year 1982 appropriated levels. To me that represents a going out of business operation, not only in those fields but in some others. It concerns me greatly that we are forsaking the future.

Dr. **STEVER**. I would like to make a comment there. In answer to Mrs. Bouquard's question about the appropriate Government role, I mentioned filling gaps. I think energy is such a broad field that there again the Government should be selective. There are some areas of the energy field in which industry and the private sector are quite capable of doing what needs to be done and there are areas in which they are not. So selectivity is important, you don't just say we have to be in energy, you have to say we have got to be in this part or that part of energy. Again, I detected some element of this view in Dr. Keyworth's testimony.

Mr. **FUQUA**. I want to thank both of you. Before we adjourn, without objection, the formal statements by members will be accepted as part of the record of the hearing.

I want to thank you, Dr. Stever, and you, Dr. Press, for taking time to be here. I think this hearing has been most helpful and as we try to grapple with the decisions that we are going to have to be making, particularly in the 1983 budget year and the impact that it is going to have on our national well-being.

I thank you very much for your contribution.

The meeting is adjourned.

[Whereupon, at 12:20 p.m., the committee was adjourned.]

[Additional correspondence for the record follows:]

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
(202) 225-6371

January 25, 1982

Dr. George Keyworth
Director
Office of Science and Technology Policy
Executive Office of the President
Washington, D. C. 20500

Jay

Dear Dr. Keyworth:

I want to thank you for your excellent testimony before the Committee on Science and Technology on December 10, 1981. At the hearing on U. S. Science and Technology Under Budget Stress you indicated that you would respond to additional questions or inquiries from Committee Members.

During the discussion following your prepared statement, you indicated that you "desire to support a strong space science program across three general areas... planetary exploration, solar-terrestrial science, and astronomy and astrophysics." The Committee would appreciate some elaboration of the proposed program for these three areas of space science.

In addition, Mrs. Schneider has submitted the attached question on funding for women and minority scientists.

The Committee looks forward to receiving your response at your earliest convenience.

Sincerely,

Don

DON FUQUA
Chairman

DF:Hwm
Enclosure

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Committees:
MERCHANT MARINE
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Subcommittees:
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CONSERVATION AND THE
ENVIRONMENT
OCEANOGRAPHY

SCIENCE AND TECHNOLOGY

Subcommittees:
ENERGY DEVELOPMENT
AND APPLICATIONS
NATURAL RESOURCES,
AGRICULTURAL RESEARCH,
AND ENVIRONMENT

Question submitted by Mrs. Schneider to Dr. George Keyworth as a follow-up to the hearing on the impact of the current budget stress on the health of American science and technology on December 10, 1981.

In this time of budget cutbacks, how can we ensure that those who are at the beginning of the scientific ladder, without a proven track record, but having a lot of promise, will be able to obtain funding? As you know, without initial funding, scientists can never build a track record. I am especially worried about women and minority scientists who traditionally have had a more difficult time obtaining this initial funding.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20500

February 11, 1982

Dear Don:

In response to your letter of January 25, I appreciate the opportunity to elaborate on my testimony of December 10, 1981, as well as to respond to Mrs. Schneider's question.

During the discussion on December 10, following my prepared statement, I was asked if I had "recommended against the continuation of NASA's planetary program." As I stated in my response, "planetary research, planetary exploration has dominated the American space science program for more than the last decade. We intend to support a strong program across the three general areas of what I will call space science: planetary exploration, solar terrestrial science, and astronomy and astrophysics.

I believe that in assuring the maximum exploitation of the shuttle it will be necessary to place more emphasis on the solar-terrestrial science and astronomy and astrophysics areas, and that planetary exploration may, in a relative sense, decline as these other areas take a larger portion of the space science budget. Our objective is not to diminish the highly successful planetary exploration program, but rather to strengthen other rich areas of science. The Gamma-Ray Observatory is an example of an activity which can accomplish this.

In my statement I did not intend to convey the impression that I had a specific proposal, or family of proposals, which would illustrate such a program. I am working with NASA and the scientific community toward definition of a program that meets this criteria. I am certain that we, the Executive Branch and the Congress, can work together to identify priority efforts in each of these areas that are focused upon specific objectives selected on the basis of their expected contributions to fundamental science that will result in a strong and comprehensive U.S. space program.

In response to Mrs. Schneider's question, the Administration is strongly committed to supporting meritorious research proposals from whatever source. Studies of NSF's peer review process have shown that the institution or "name" of the researcher does not substantially influence the award of research grants.

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AND TECHNOLOGY

The Administration is also fully committed to the more effective use of our national resources. In the area of science, this clearly includes young women and minority scientists and engineers. The Administration recognizes various historical factors, such as a lack of collegial support, may have resulted in underutilization of our full manpower resources in the past. I have discussed this issue with John Slaughter, the Director of the NSF, and I understand that he is working on ways to promote greater participation of minorities and women in science and engineering.

Please let me know if you need further elaboration on these or other topics.

Very truly yours,

Jay

G. A. Keyworth

The Honorable Don Fuqua
Chairman
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS

TUESDAY, FEBRUARY 2, 1982

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to notice, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Present: Representatives Fuqua, Roe, Brown, Bouquard, Flippo, Glickman, Nelson, Shamansky, Dymally, Winn, Fish, Lujan, Heckler, Sensenbrenner, Weber, Gregg, Schneider, and Lowery.

Staff present: Dr. Harold Hanson, executive director; Dr. Ezra Heitowit, science consultant; and Dr. John Holmfeld, science policy staff..

Mr. Fuqua. This morning we resume the hearings that began on December 10 to examine the impact of current budget stress on the vitality of U.S. science and technology. Frank Press's October National Academy of Sciences meeting on the science budget had formalized and highlighted urgent discussion within the scientific and technical communities on how to best react to that stress.

At our hearing in December we received a major statement from the President's science adviser concerning the administration's view of how high priority science efforts can be maintained. Two former science advisers, Dr. Press and Dr. Stever, raised some of the many issues always triggered by priority-setting exercises for science. These include the need for investment continuity, the weakness of our foresight on what will or will not pay off, and the unfortunate power of budget expediencies to dominate long-term decision-making for science and technology.

The coming three days of hearings provide a means to include in this process an important dialogue between the scientific and political communities. We will have informal meetings as well and hope that a continuing close contact will be maintained. This phase of the hearing is especially significant as it is a direct prologue to congressional budget authorization actions which will be initiated by our committee in the coming weeks.

Prior to those decisions, we need very much to have the benefit of any ideas the science community can offer us on how to minimize the long-range damage to national science and technology capabilities brought about by current budget pressure. We need to be made aware of any sense of priorities for use of scarce resources which is emerging in the community. We need to understand whether there is a way of administering budget restraint which will allow orderly planning, avoid wasteful fits and starts, and maintain the most important of our technical capabilities for the future.

We need also to understand the extent of the disruptions and dislocations which are currently occurring in the science community due to budget actions of the past year. This information is needed so that we can weigh the urgency of emphasizing resources in this sector, as opposed to the many other areas of public concern clamoring for attention. More than anything else, I think we need guidance from our distinguished witnesses concerning the impact on science of the nearly complete politicizing of the Federal budget which we have seen in recent years.

We are all politicians on the committee, so we can certainly understand that budget debates are a form of political debate. But the committee also has a special stewardship responsibility for the health of our Nation's science and technology enterprise. We have seen too vividly that when long-term science funding is coupled casually to ever-shifting short-term budget politics the result will be a disaster of uncertainty and disruption. The administration clearly has used the budget as the main vehicle for expression of a broad theory of acceptable government.

The debate on that broad theory has been a healthy one, I feel, and one on which I shared many of the views of President Reagan. I cannot support, however, actions in which the theory has been blindly applied with a wasteful loss of trained manpower and developed technical capabilities or with neglect of needed long-range science and technical investments for national security and wellbeing.

With generally good results, this country and its Congress have never had much patience with economic theory as opposed to hardheaded pragmatism. To the extent that current science budgets express economic or political theory at the expense of wise stewardship of science and technology resources, I think that Members on both sides of the aisle will want to assert the traditional pragmatism through congressional revision of administration budget proposals. I hope the witnesses in the next 3 days will help guide us to areas where these pragmatic adjustments are needed.

We are grateful that our witnesses who are here to testify today. You have a list of these witnesses before you. We will take the witnesses individually and then have the questions at the end, because I think it will help expedite the meeting this morning, but I also think many of the questions have relevance that maybe other witnesses would like to comment on.

[The prepared statement of Congressman Larry Winn, Jr., ranking minority member, follows:]

STATEMENT OF HON. LARRY WINN, JR.

Mr. Chairman, I look forward to the three days of hearings that we have scheduled on this topic this week. As you know, we had one day of hearings on this subject when Dr. George Keyworth, the President's Science Adviser, presented a very bold and innovative program and science policy of the Administration.

Since that time, the National Science Board has released its latest volume of science indicators. I think some of the findings in that report are extremely interesting. For example, national levels of basic research activity, measured by funding for basic research, have risen continuously since the mid 1970s. The rate of increase declined somewhat in 1980 and 1981. However, it is important to note that we are still talking about a rate of increase and that funding for basic research has not been static. This excellent report also points out that industrial basic research is on the rise again. By 1981, industry, which performs about 18 percent of U.S. basic research, is expected to spend at a basic research level about 37 percent more than in 1975 measured in constant dollars. These science indicators also show that industry performs about 48 percent of our research and development efforts over all. I would certainly expect that with the tax incentives contained in legislation passed last year by the Congress, that we are going to see a beneficial increase in this trend.

Mr. Chairman, I hope that over the next three days, our various witnesses will be able to shed additional light on these trends. I am confident that the picture they will paint will be one of overall health for the U.S. research and development community in general and our basic research effort in particular.

Mr. FUQUA. At this time I would like to call on our colleague from Alabama, Mr. Flippo. Do you have a statement you wish to make?

Mr. FLIPPO. Mr. Chairman, in the interests of expediency, may I file my statement for the record, please?

Mr. FUQUA. Without objection, it will be made a part of the record.

[The opening statement of Mr. Flippo follows:]

OPENING STATEMENT
BY THE
HONORABLE RONNIE FLIPPO

HEARINGS ON U.S. SCIENCE AND TECHNOLOGY
UNDER BUDGET STRESS

Feb. 2, 1982

MR. CHAIRMAN, I want to say just a few words about why I think these hearings are important and what I think we need to accomplish.

We all know there are pressures to reduce the Federal budget with the very worthwhile goal of getting our economy under control. The R&D budget is discretionary and can be cut.

So through hearings such as these we need to know what will happen if we reduce Federal funding for R&D. That is, we know that our R&D successes of the past have contributed to our economic strength, so we need to be assured that the supply-side benefits of cutting the Federal budget will offset possible negative impacts of cutting programs.

In other words we may decide to cut the budget, but let's do it carefully. Let's know what needs to be cut and why.

Last December 10, Presidential Science Adviser George Keyworth presented the Administration philosophy with respect to the R&D budget. With all due respect, Dr. Keyworth's statement left some questions.

There seems to be some confusion between ends and means or between indicators and root causes in the thinking presented on December 10. Let me be specific.

First, Dr. Keyworth suggests that the health of U.S. science can be measured in part by the number of Nobel prizes won.

Of course that is in part true;but it is not particularly relevant to consideration of the 1983 budget. The Nobel prizes won in the last several years--and the U.S. has won many--were awarded for work done earlier and funded yet earlier, perhaps 20 years ago. So the real question we need answered is, what impact will the 1983 budget have on Nobel prizes in 2003?

It is interesting that much of the work which resulted in recent Nobel prizes was done during periods of high growth of Federal funding of R&D. I mention this because Dr. Keyworth made the point that in times of high growth we may not do our best science and that the decades of growth of science funding are over. Yet Dr. Frank Press testified at the same hearing that there has been little or no growth in the buying power of Federal funding of R&D for perhaps 15 years. So it is not clear whether there is any connection between growth, past Nobel prizes, quality, and the 1983 budget.

There seems to be some confusion here. Growth *per se* is neither good nor bad, but if we need more R&D, the budget may have to grow.

Of course if we need less R&D the budget may have to shrink.

This brings me to another possibly misleading statement. Dr. Keyworth said budget cuts could be good for R&D if we make them wisely. This is because the average quality will go up if the weaker projects are cut. Again, this is true but not very helpful. Earlier in my career I was an accountant. I know that if you strike all the smaller numbers out of a column of figures, the average will go up, but the sum will go down.

So Dr. Keyworth's argument about average quality is not especially informative. If all we wanted to do was raise the average quality we would give one grant to Albert Einstein and stop. But since we fund R&D for various reasons, we need to look at the total program, at where it is going and why. Worrying about average quality again confuses ends and means. We should relate cuts in R&D to national goals, and for example we should balance the need to improve productivity through R&D against the need to reduce the budget.

A second issue related to quality of science was discussed December 10 in a relatively unfruitful way. There was an attempt to put "excellence" in logical opposition to "geographical distribution of funds." This is a false opposition. What we in the Congress tend to be interested in is the geographical distribution of excellence. We believe this is possible and desireable: Desireable because the conduct of R&D provides benefits to the locale where it is done.

Of course Federal funds are the means to achieve this desireable goal, but let's not confuse the end with the means. Such confusion does not help us work with the 1983 budget.

Mr. Chairman, this statement has been over long, but I think the hearings are very important and that several areas of confusion need to be clarified. So I thank you for bearing with me, and look forward to the testimony.

Mr. **Fuqua**. I will now call on our distinguished colleague, George Brown, to present our first witness.

Mr. **Brown**. Mr. Chairman, I am grateful for the opportunity to introduce Dr. Saxon. He is a distinguished scientist who serves as head of what I, of course, consider to be the greatest university in the country, the University of California. But I am sure his views are not parochial, since he owes his own education to another great institution, MIT, which I suppose can make some claims to qualities of excellence.

I should point out that Dr. Saxon also spent most of his academic career at UCLA, where I spent more years than I like to recall. He has done an excellent job as the spokesman for the academic community and the scientific community in many areas.

It is a real pleasure to welcome his contribution to this extremely important national, political issue of how we deal with the funding of science and technology in situations where we have a great scarcity of money for the funding of all the important things this country needs. I look forward to Dr. Saxon's contribution.

Mr. **Fuqua**. Thank you, Mr. Brown.

Before Dr. Saxon begins, we would also like to ask unanimous consent that the statement by Congressman Winn be presented in the record following my statement.

Dr. Saxon, we are very happy to have you here today.

[The biographical sketch of Dr. Saxon follows:]

DAVID STEPHEN SAXON

Born: February 8, 1920, St. Paul, Minnesota

Education:

B.S. degree, 1941, Massachusetts Institute of Technology
Ph.D. degree, 1944, Massachusetts Institute of Technology

Wife:

Shirley Goodman Saxon. They have six daughters.

Professional positions:

1944-46	Staff member, Radiation Laboratory, Massachusetts Institute of Technology
1946-47	Associate Physicist, Phillips Laboratories, New York
1947-50	Assistant Professor of Physics, University of California, Los Angeles
1950-51	Physicist, National Bureau of Standards and Visiting Associate Professor, University of Southern California
1952-57	Assistant Professor to Professor, UCLA
1958---	Professor of Physics, UCLA
1963-66	Dean of Physical Sciences, UCLA
1968-72	Vice Chancellor, UCLA
1974-75	Executive Vice Chancellor, UCLA
1975---	President of the University (became the 14th UC President)

Academic Fields:

Theoretical physics, nuclear physics, quantum mechanics and electromagnetic theory

Honors and Awards:

Guggenheim Fellow at the Institute of Theoretical Physics in Copenhagen (1956-57)
Guggenheim Fellow at the University of Paris (1961-62)
Fulbright Award (1961-62)
Distinguisehd Teaching Award, UCLA (1967)
Honorary Alumnus of UCLA by the Alumni Association (1975)
Awarded degree of Doctor of Humane Letters, honoris causa, by the Hebrew Union College—Jewish Institute of Religion (1976)
Awarded an honorary Doctorate of Humane Letters by University of Judaism (1977)
Honorary Doctorate of Laws by University of Southern California (1978)
Honorary Doctorate of Science by University of British Columbia (1980)

Memberships:

American Physical Society
American Association of Physics Teachers
American Institute of Physics
Sigma XI and Sigma Pi Sigma
Constitutional Rights Foundation
Corporation of the Massachusetts Institute of Technology (governing board, 1977-82)

Publications:

Contributor of many articles to professional journals in his field, also author of several physics texts.

STATEMENT OF DAVID S. SAXON, PRESIDENT, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

Dr. **Saxon**. I am very grateful for the opportunity to be here, Mr. Chairman.

I have submitted in advance a prepared statement of some length, and with your permission I would like to offer that.

Mr. **Fuqua**. Without objection, we will make the statement in its entirety a part of the record. If you wish to summarize and make additional comments, we would be most grateful.

Dr. **Saxon**. Thank you. That is what I will do.

I am David Saxon, president of the University of California which, with its 9 campuses, its 5 medical schools, its 150 organized research units, and its 4 national laboratories is all by itself a significant part of the scientific capacity of this country.

Like most other research universities, whatever the source of their general support, our capacity for scientific research and advanced scientific education is utterly dependent on continued assistance from the Federal Government. It is from that perspective that I want to give you my views on the condition of scientific research and advanced scientific education in the Nation today. I want to do so in the perspective of the next decade and in the context of the policies of the Reagan administration.

Among the topics I will touch on briefly are the importance of science to the country generally; my concern about sustaining it in a period of retrenchment; the need to educate the next generation of scientists and engineers, and the next after that; the need for a national forum to develop guiding principles for science policy; the need for appropriate levels of support, public and private; and the need for a free flow of scientific information.

President Reagan's science adviser, my former colleague, George Keyworth, emphasizing the importance to the Nation of the scientific enterprise, said to this committee last month:

> The Reagan administration places great value on our country's scientific and technological strength. Supporting science is a necessity for all great nations, and certainly for the United States. Success in achieving virtually all of our national goals for the 1980's—more vigorous economic growth, enhanced national security, a stronger competitive position in world markets, better health and quality of life for all of our people—will depend in large part on knowledge and technological developments which can only come from scientific research.

That is what Dr. Keyworth said to this committee, and I could not agree more with his statement. My concern arises from my skepticism about whether, within its overall program, the administration will succeed in sustaining science as a vital national effort or whether, by the unintended side effects of policies directed toward reducing the relative size of the Federal Government, some serious, costly, and even permanent damage to science will result.

We are all aware, of course, of the President's efforts to control the growth of Federal expenditures and indebtedness, efforts which are intended to free resources to stimulate the economy. At least in the short run, the economy is in recession, a situation which makes the President's task more difficult as revenues are reduced and money remains expensive. Nevertheless, the administration is operating on the expectation that its efforts will be successful and that a surge in production will begin. Therefore, it seems to me particularly unwise to make drastic cuts in just those programs that are vital to the economy's health over the long run.

It does not make sense, for example, to reduce current support for scientific research when the results of that research will be needed in the future. It does not make sense to reduce support that enables students to attend college, and particularly to continue study at the graduate level. It does not make sense to diminish resources available for the much needed improvement of scientific education throughout the school system, from kindergarten to graduate school.

It does not make sense to impose, by selective budget cutting, decisions about what part of the scientific endeavor should be supported without the most careful and extensive consultation and discussion. It does not make sense to force on the States responsibilities that they are unable to meet.

From my perspective, I see an administration that correctly expects, and even demands, much from science and technology but without making available the kind of support needed if those expectations are to be realized.

I know that this committee is mindful of the tight connection between its concerns about American science and technology and support for the education of the next generation of scientists and engineers. Cuts in financial aid, particularly for graduate students, are a matter this committee cannot afford to ignore.

The Guaranteed Student Loan Program, a major source of support for graduate students, is critical to maintaining the vitality of our advanced education in the immediate future. In 1980-81, for example, more than a quarter of the graduate students at my university received support from that program. The idea of barring graduate students from eligibility is not sound policy in the face of continued national need for their education.

I also want to emphasize an important link between the health of our scientific enterprise and the whole question of access to higher education. The need to assure equal educational opportunity is more than a matter of simple justice. The truth is that we cannot afford to neglect any source of talent.

There is also a great need for improvement in science and mathematics education at all levels, a need that is fortunately receiving more attention from the States these days, including California. But given the severe financial limits the States must face, it may be neither wise nor possible to rely solely on local efforts to accomplish needed improvements. In my opinion, the Federal Government, in cooperation with the States, should retain a substantial role in encouraging this sort of educational effort.

Incentives and inducements to draw talented young people into scientific research are also necessary. Fellowship programs are valuable and effective. I am encouraged to hear of proposals from other Government agencies as well as from the private sector for targeted fellowships with stipends that are realistic for these times, and I urge this committee to give continued attention to the vitality of the National Science Foundation's science education effort and especially its fellowship program.

The most important incentive for young people to pursue the rigors of a scientific education is the vigor and excitement of the scientific enterprise in university departments and laboratories. In this connection, the current environment of fiscal uncertainty regarding support for science is surely doing short-term damage to morale and perhaps long-term damage, too.

At the University of California, the case I know best, we estimate that since the passage of the continuing resolution last December our overall research support from Federal agencies in fiscal year 1982 may decline as much as $25 million in current dollars. In the face of inflation, we estimate that the effective decline in purchasing power for research from fiscal year 1981 to fiscal year 1982 is 10 percent of our Federal research support. This is the equivalent of $60 million current dollars.

My prepared statement, which I mentioned earlier, contains examples of how these cuts are affecting our campuses and laboratories. Some of them involve two or three people; some of them involve hundreds of people. None of the cases I cited are going to bring the Nation's scientific effort to a grinding stop, but the cumulative cost to the country to terms of wasted time, wasted effort, and lost morale is enormous.

Difficult as current economic circumstances may be, the need for stability and continuity is profound. I hear that everywhere I go, talking to my colleagues about the current situation. At the same time, we need a focused and cooperative effort among government, industry, and universities to develop science policies and plans. The National Commission on Research has recommended the creation of a forum that will include representatives of all interested institutions. I support this idea.

We need a principle of reliable support. We need some understanding of the desirable mix of fundamental research, applied science, and development. We need a principle to guide us in determining the long- and the short-term pertinence of research. We need a principle of balance among public and private agencies to sustain diversity of support as well as balance among performers. Finally, we need a principle that assures that excellence prevails over political and geographical considerations.

I hope Congress and the administration will take the lead in establishing such a forum to help us clarify these important matters. The National Academy of Sciences has a committee which is looking very hard at this question.

One of the questions that needs to be answered is, How much is enough when we talk about support of science? Dr. Keyworth is dubious about what he calls arbitrary standards of support, such as a percentage of the gross national product. He is also dubious about the level of quality and the means for its evaluation. I think that by emphasizing the apparently arbitrary character of such standards, he directs attention to the wrong issue.

The best evidence that Federal support for basic scientific research yields work of high quality is the overall success of our scientific enterprise. It is remarkable, in fact, that so much has been accomplished, given the obstacles that must be overcome. The Association of American Universities and the National Science Foundation, for example, have documented the obsolescence of scientific equipment and instrumentation in universities compared either to industry or to other advanced countries.

The same problem regarding facilities has been documented. I am convinced that we are unable to support, through project awards, much proposed research that would be valuable. And I do not think we are supporting a great deal that is not worthwhile. I therefore hope that the country can find a way to accept present levels as a minimum baseline and to plan on a rate of real growth of 1 or 2 percent per year for the next decade, as suggested to this committee by Dr. Frank Press. Such a slow but steady rate of growth is a prudent approach to the need to absorb new investigators and to allow for some predictable increase in the cost of instrumentation and equipment.

I also agree with Dr. Press that government and academic science should seek a compact with industry that will lead to increased cooperation and funding from that sector. I think that further amendment of the tax laws to accomplish this purpose is desirable, but it is very important that it be understood that support from private sources can never substitute for Federal support.

In my own institution we receive a great deal of private funding. We work very hard to get it. But all of our research contracts from the private sector, all of our grants, all the donations of equipment and fellowships and unrestricted funds from industrial firms and their foundations amount to 5 percent of our research budget. That amount will not grow much in coming years. It cannot make up for drastic cutbacks in Federal money, Federal money for research, for education, for student support.

It is important that those of us who are committed to sustaining scientific research, education, and training also support the institutional needs that permit the system to work. Such support should be linked to performance, not serve as a program of Federal subsidies to universities as such. I am thinking here of something analogous to the management allowance that is paid to those institutions that operate national laboratories for the Government.

Such an allowance could be allocated according to the schedule related to the total amount of federally sponsored research undertaken. Such an allowance would permit much more flexible and effective management of the talented people, ranging from the business officers and machinists to the senior scholars who make the system work.

To return to the question of how we assure excellence in a decentralized system driven by competition: the competitive project grant method should be the core of the system. The introduction of the understandable political need to distribute resources by some standard of equity among regions and institutions rather than by the standard of scientific excellence would be most unfortunate, in my view. For that process can be carried out only at the cost of declining quality, especially, I must emphasize, under circumstances of economic stress.

For those scientific establishments such as the national laboratories—and we have four of them under our jurisdiction—which are maintained on a less competitive basis, the operating institutions, together with the sponsoring agency, must be prepared for the most rigorous scrutiny. In the large laboratories the University of California operates for DOE, we maintain a system of oversight and scientific scrutiny that we are confident does a good job of quality control. It has not been easy, but I believe it is working.

Finally, I must say a word about the value of the free flow of scientific data and information that is so typical of American science. I am convinced that it is a necessary condition of our success. In the past year a controversy has developed within the Government, between Government agencies and universities, that poses a serious threat to this scientific openness. This controversy arises from a justifiable anxiety—and that word "justifiable" is used advisedly—about the rapid technological advances on the part of this country's political adversaries and economic competitors.

As you are aware, university-based science and education are open to foreign students and scholars, and American scholars and students frequently cooperate with institutions abroad. It is being proposed, then, that export control regulations be revised and interpreted to apply to various research activities in universities in ways that would require restrictions on persons and papers—published papers—that we cannot implement or accept. We believe that to do so would so inhibit and interfere with the conduct of research and advanced teaching that its cost would far exceed any benefit in terms of slowing the advance of other nations.

I believe there is a solution to this matter that would involve a reasonable mix of some security classification, some immigration control, and some good faith, and I know that responsible officials are working for such a solution. I hope that political rhetoric—on either the universities' or the Government's side—will not destroy this process.

Let me sum up. I am encouraged by the administration's avowed policy of support for scientific research, but I am concerned that, in the process of cutting support for students and for research, serious damage may be done to our scientific capacity.

Maintaining our ability to educate the next generation of scientists and giving appropriate attention to encouraging the work of the current generation of scientists are both important. The Nation needs a better and more orderly means of making science policy and planning for the future, one that is adapted to our pluralistic system. It must be capable of providing guidance on reliability of support, on the mix of basic and applied research and development, on the balance among sources of support and performers of research, and the on the means to assure excellence and pertinence of work.

The country's scientific capacity needs predictable support that provides for up-to-date equipment, adequate facilities, and some growth. Finally, I believe that sustained excellence in science is of the highest importance to the Nation.

May I thank you again for the opportunity to appear before you? I hope my remarks have been helpful, and I will be pleased to respond to questions in due course.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Saxon follows:]

STATEMENT OF DR. DAVID S. SAXON, PRESIDENT, UNIVERSITY OF CALIFORNIA

I am David Saxon, President of the University of California, which with its nine campuses, five health sciences schools, 150 organized research units, and four national laboratories, is a significant part of the scientific capacity of this country. My colleagues on the Board of Regents, the faculty, the administration and I are always conscious of our responsibility to help maintain the vitality of the nation's research capacity and to constantly renew it by educating young people to become fruitful members of the scientific and technical community. We are also committed to the use of this great capacity in the service of our own state and of the nation. Although the University is adequately supported—and even generously supported, speaking historically—by the State of California, our capacity for scientific research and advanced scientific education is utterly dependent on continued assistance from the federal government. It is from that perspective that I want to give you my views on the condition of science as an endeavor of great complexity and strength and of great social, cultural and economic value—but an endeavor which is far from invulnerable to damage and decline. I want to do so in the perspective of the next decade and in the context of the new policies coming from the administration of President Reagan. Specifically, I will touch on the following points:

- the importance and utility of the scientific effort to the country;
- my concern about sustaining science in this period of retrenchment;
- signs of disruption in the scientific enterprise;
- the importance of the education of the next generation of scientists and engineers;
- support by private enterprise;
- appropriate level of support;
- the need for a national forum to develop guiding principles for science policy;
- the need for a free flow of scientific information.

I am grateful to this committee for the opportunity to speak to you today.

On December 10, my former colleague, George Keyworth, Director of the Office of Science and Technology Policy, said to this committee:

> "The Reagan Administration places great value on our country's scientific and technological strength. Supporting science is a necessity for all great nations, and certainly for the United States. Success in achieving virtually all of our national goals for the 1980s—more vigorous economic growth, enhanced national security, a stronger competitive position in world markets, better health and quality of life for all our people—will depend in large part on knowledge and technological developments which can come only from scientific research.
>
> "Science is a critical factor in determining our ability and readiness to meet the problems of the unforeseeable future. No one can tell at this time what all the problems of our society will be. But we can be sure that many of them will be inextricably tied to science, and that our future problem-solving capability will depend on the depth and breadth of our scientific knowledge, particularly upon the type of breakthrough that comes from basic research."

I could not agree more with Dr. Keyworth's assessment of the importance and utility of the scientific effort of the country. I am gratified at his affirmation of the present administration's high evaluation of the importance of science and technology. He went on to say that, "this Administration views basic research as a vital investment with good return and believes that, as a contribution to overall national security and economic strength, we must maintain health across the spectrum of science, striving for excellence in all these fields". I believe we can all agree with such an assessment.

My concern arises from my skepticism about whether, within its overall program, the Administration will succeed in sustaining science as a vital national effort or whether, by the unintended side effects of policies directed toward reducing the relative size of the federal government, some serious, costly, and even permanent damage to science will result.

It is important to remember that America's scientific capacity, as developed over the past three or four decades, is an accomplishment unique in history. Its vigor and excellence are sources of great national pride and strength. But it is also important to appreciate that American science today is troubled by some grave difficulties in terms of attracting enough new talent, obtaining required instrumentation, and providing adequate facilities. These difficulties are exacerbated by other and related national problems. Among those problems are a national industrial base that is plagued by obsolescence, capital shortages, financial uncertainties, and of course the nation's economic troubles generally.

We are all well aware of the President's efforts to control the growth of federal expenditures and indebtedness, efforts which are intended to free resources to stimulate the economy's productivity. We are now in a period of large reduction in federal program budgets--a period that is expected to continue for a while yet. At least in the short run, the economy is in recession, a situation which makes the President's task even more difficult as revenues are reduced and money remains expensive. Nevertheless, the Administration is operating on the expectation that its efforts will be successful, and that a surge in production will begin. Therefore, it seems to me particularly unwise to make drastic cuts in just those programs that, as Dr. Keyworth points out, are vital to the economy's long term health. What I have in mind is the maintenance of a vigorous fundamental scientific capacity, including as a critical element the capacity to educate young people as scientists, engineers, and technicians. I believe that for these reasons resources must be made available to assure the education of young scientists and to keep the country's basic research effort vigorous.

In short, it does not make sense to reduce the current support of scientific research the results of which will be needed in the future. It does not make sense to reduce support that enables students to attend college, and particularly to continue their studies as graduate students. It does not make sense to diminish resources available for improvement of scientific education throughout the school system. It does not make sense to impose, by selective budget cutting, decisions about what parts of the scientific endeavor should be supported without any consultation or policy discussion. It does not make sense to force on the states responsibility for expectations that they are unable to meet.

Thus, from my perspective there seem to be mixed signs and portents in Administration policies affecting science and technology, particularly in universities. I seem to see an Administration policy that makes demands on science and technology without making available the resources needed to meet those demands.

Members of this committee are certainly aware of the importance of universities in the performance of basic science in this country. For the past decade universities have consistently performed about half the basic research in the nation. They employ about 40% of all scientists and engineers performing basic research, and about 70% of the doctoral level basic research staff. A very large proportion of these doctoral level research people are also engaged simultaneously in teaching.

This system, uniquely American in character, has compiled a remarkable record of productivity, flexibility, and economy. One reason for that is the way American higher education relates so intimately scientific research to the scientific and technical education of our students. Universities provide an environment of intellectual freedom infused with a healthy ethos of competition and stimulated by a ready flow of young talent. Although no one would want to claim that it is perfect, particularly in the face of barriers that still exist to the poor and ethnically disadvantaged, it is in principle an excellent system and in practice a good one. Those who seek to support vigorous scientific research have an important stake in the vitality of our educational system.

I realize that this committee does not have responsibility for most of the federal government's educational programs. But I am certain that you are mindful of the tight connection between your concerns about American science and technology and support for the education of our next generation of scientists and engineers. I must say that actual and rumored cuts in the availability of financial aid, particularly for graduate students, is a matter that this committee cannot afford to ignore. The Guaranteed Student Loan program, a major source of support for graduate students, is critical to maintaining the vitality of our advanced education in the immediate future. In 1980-81, 27% of the graduate students at the University of California received support from the GSL program. This money was 39% of all financial aid going to graduate students that year. I cannot argue that the cost of the program should not be constrained in some reasonable way, particularly by linking eligibility to some standard of need. But the idea of completely barring graduate students from eligibility is not a sound policy in the face of continued national need for their education.

I also want to suggest an important link between the health of our scientific enterprise and access to education. We have heard a great deal in recent decades about equal educational opportunity. The need to assure equal opportunity is a matter of simple justice. But there are practical reasons as well. In this era of international competition in the field of technical accomplishment, in the areas of defense and industry, in all aspects of scientific achievement, we cannot afford to neglect any source of possible talent. There is no doubt in my mind of the importance of such milestones of legislation as the GI Bill, NDEA, and the Higher Education Act, all of which have made enormous contributions to the quality of recent generations of scientists. Federal efforts in this area are extremely important.

The improvement of scientific and technical education in general is a much more intractable problem. Because of competition from industry, we are facing the dual problem in engineering of retaining faculty and attracting new students into graduate school. We have decided at the University of California that circumstances have made it necessary to establish a higher salary scale for engineering faculty as an initial way to address this problem. But we must also have support for graduate students. I am happy to report that in California, and I know in other states as well, governors and legislatures are becoming attentive to the great need for improvement of education in science and mathematics in elementary and secondary schools, as well as for improvement in technical training, engineering education, and scientific education in colleges and universities. This interest is being stimulated by a healthy competition to make various localities attractive to high technology industry. But the resources of these states are also severely limited. It may be neither wise nor possible for the nation to rely solely on local efforts to accomplish needed improvements. In my opinion, the federal government, in cooperation with the states, should retain a substantial role in encouraging this sort of educational effort.

While a broad educational base is important to the strength of science, incentives and inducements to draw talented young people into scientific research are also necessary. Fellowship programs, of which the NSF Science Fellowship is the archetype, are extremely valuable and effective. I am encouraged to hear of proposals from other government agencies as well as from the private sector for targeted fellowships with stipends that are realistic for these times. I was also pleased that Congress was able to save the NSF program during the past budget year. I urge this committee to give continued attention to the vitality of the NSF science education effort.

The most important incentive for young people to pursue the rigors of a scientific education is the vigor and excitement of the scientific enterprise in university departments and laboratories. The current doubts cast upon the future of science, on top of a decade of ups and downs in federal funding, have to some extent undermined the morale of the enterprise and its attractiveness. This situation is to me the most alarming effect of the confusion resulting from the present Administration's attitudes and performance. The environment of uncertainty is surely doing short term damage. It may very well have severe long term consequences also.

At the University of California, we have been trying to assess the present and prospective effects of the various proposed and enacted budgets affecting our research support. In this environment of uncertainty, the need to establish some guideposts is essential. We need to plan and we need to limit as best we can the unsettling and counter productive anxieties on the part of faculty and graduate students that may discourage them.

Since the passage of the continuing resolution of December, we estimate that our overall research support from federal agencies in FY 1982 may decline as much as $25 million in current dollars. In the face of inflation we estimate that the effective decline in purchasing power for research from FY 1981 to FY 1982 is 10% of our federal research support. This is the equivalent of $60 million in current dollars.

This sort of cut is obviously difficult to deal with, and all the more because it is an aggregate of the net of various cuts and increases. The resulting uncertainty, and even turbulence, is substantial.

Let me give you a few examples of what I mean. At one of our campuses there is a project supported by NASA due to expire at the end of January 1982. We submitted a proposal for renewal in the amount of $205,000. In November we were asked to reduce the budget to $170,000. In January we were advised that funds were not yet available for renewal. The principal investigator was told by NASA people that they were making every effort to provide funds. We were not, however, able to get a sufficiently firm commitment so that we could allow the project to continue beyond January 31. Thus it was necessary to issue lay-off notices and take steps to shut down. Two graduate students, a half-time post doctoral physicist, and other people were on the project payroll.

In another example, a project from the National Institute of Child Health and Development to study causes of dyslexia--a form of reading disability--in children was abruptly terminated. Three years of data which suggested significant advances in scientific understanding of the disorder now cannot be analyzed and reported. Most of the members of the research team, including an internationally renowned investigator, are seeking other positions.

A third example is the Lawrence Berkeley Laboratory, which is on the Berkeley campus and in many ways closely tied to departments there. The operating funds for the laboratory have been reduced from about $133 million in FY 1981 to about $119 million after the December continuing resolution. An effect of this is a reduction in career staff of 315 employees and 120 contract people. Funding in nuclear physics is the same in current dollars and eroded substantially by inflation, particularly the cost of electric power. Research in life sciences, conservation, nuclear waste management and geothermal energy have all been reduced substantially. The loss to the laboratory of highly skilled and long term employees is very disturbing to morale.

None of these cases will bring the nation's scientific effort to a halt. But the cumulative cost in wasted time and effort, and especially in morale, is enormous. I do not think the country can afford such waste, nor can it afford the risk of discouraging young people. Unless we think clearly about the human dimensions of the scientific enterprise, we will continue to permit or even to induce a dangerous loss of enthusiasm and creativity. Both are indispensable to the health of our scientific activities.

I do not mean to ignore the difficult economic environment of the country. But it seems clear to me that we must continue to spend money to support scientific research and education as an investment in the future. Moreover, the need for stability and continuity in funding is profound. We must assure the continued flow of talented young people into scientific fields. We must strive to sustain effective research teams, and we must provide them with the equipment, instrumentation, and facilities they need. As Dr. Keyworth noted, it is a vital investment that will pay for itself many times over.

The Administration, Congress, and the scientific, academic and industrial communities must work together to clarify their respective responsibilities, to develop plans appropriate to our pluralistic system, and to provide ways to guide future courses of action. However constraining our present economic circumstances may be, we must not lose our confidence in the underlying strength of our economy. And certainly the major sectors of the economy—industry, energy, agriculture, and services—will continue to need the results of research on the physical, chemical, and biological aspects of nature; on the earth, its climate, and the space around it; on materials, techniques, processes; and social phenomena. They will need trained and creative people. They need to be confident that these requirements will be met.

The diversity and decentralization of our system for carrying on scientific research are sources of strength that should be protected. At the same time, however, we need a focused and cooperative effort to develop policies and plans for the uncertain years ahead. The elements and principles of national science policy should be worked out with the participation of government, industry, and universities. The National Commission on Research has recommended a forum that will include all interested institutions. I support this idea. We need a principle of reliable support; we need some understanding of the desirable mix of fundamental research, applied science and development. We need a principle to guide us in determining the long and short term pertinence of research. We need a principle of balance among public and private agencies to sustain diversity of support as well as balance among performers. Finally, and most important, we need a principle that assures that excellence prevails over geographical and political considerations.

Establishing these principles seems to me particularly urgent in this time of economic competition and political pressures, both domestic and international. I hope the Congress and the Administration will take the lead in establishing an appropriate and effective forum that will help those of us who are involved in science to deal effectively with the problems we are facing today.

One of the questions that needs to be answered is, how much is enough? Dr. Keyworth seemed to be telling this committee that while the Administration accepts the responsibility of the federal government to support scientific activity, particularly basic research, he is dubious about what he calls arbitrary standards such as a percentage of GNP or whatever. He is also dubious about the level of quality and the means for its evaluation. I think that, by emphasizing the apparently arbitrary character of such standards, he directs attention to the wrong issue.

The best evidence that federal support for basic scientific research yields work of high quality is, in my opinion, the overall success of America's scientific enterprise. Science in this country has been remarkably successful by any standards, and certainly by such indicators as prizes, rates of publication, and the like. At the same time, studies by the Association of American Universities and the National Science Foundation have documented the obsolescence of scientific equipment and instrumentation in universities compared either to industry or to other advanced countries. The same problem regarding facilities has been documented. I am myself convinced that we are not able to support, through project awards, much research that would be valuable and excellent. The evidence is that there is great competition and underfunding of those projects that are selected, with concomitant forced cost sharing by universities. This fact strongly sustains the judgment that we have not reached a level of support that is wasteful.

I therefore hope that the country can find a way to accept present levels as a minimum baseline and to plan on a rate of real growth of one or two percent per year for the next decade, as suggested to this committee by Dr. Frank Press. Such a slow but steady rate of growth is a prudent approach to the need to absorb new investigators and to allow for some predictable increase in the cost of instrumentation and equipment. I also agree with Dr. Press that government and academic science should seek a compact with industry that would lead to increased cooperation and funding from that sector. I think that some further amendment of the tax laws to accomplish this purpose is desirable and proper, because I am confident that such cooperation will benefit the economy sufficiently to justify that sort of incentive. But it is very important that it be understood that support from private sources can never substitute for federal support. In my own institution, we receive a great deal of private funding. We work very hard to obtain this necessary money and we are happy to get it. We are instituting ways to work even more closely with industry to develop greater ties in the coming years. We expect more contracts and more money in the future. We expect somewhat more money as a result of new tax policies, although the actual effect of them appears to be small, about 2% greater increase than would have been the case without them according to some estimates I have seen.

But let us put our contacts with the private sector in perspective. All our research contracts, all our grants, all the donations of equipment and fellowships and unrestricted funds from industrial firms and their foundations amount to 5% of our research budget. That amount will not grow greatly in coming years; it cannot make up for drastic cutbacks in federal money--federal money for research; federal money for education; and federal money for student support.

Let me now say something about universities as complex institutions that play a central role in the organization and maintenance of scientific capacities. Until recently most universities could count on steadily increasing enrollments. Enrollment growth brought resources from the states and from students, the latter with major assistance from the federal government. The rapid rates of growth and of resources make it possible for research universities to sustain their research capacity, at what was probably less than full costs to federal sponsors. That rapid growth is over. We in the universities are necessarily more attentive to our costs in order to keep solvent. This committee is aware of one symptom of this phenomenon: the increasing controversy about indirect costs of federal research projects. It is important that those of us who are committed to sustaining scientific research, education and training support the institutional needs that permit the system to work. Such support should be linked to performance, not serve as a program of federal subsidies to universities as such. I am thinking of something analogous to the management allowance that is paid to those institutions that operate national laboratories for the government. Such an allowance could be allocated according to a schedule related to the total amount of federally sponsored research undertaken. Such an allowance would permit much more flexible and effective management of the talented people, ranging from business officers and machinists to senior scholars, who make the system work.

To return to the question about how we assure excellence in a decentralized system driven by competition: the competitive project grant method should be the core of the system. Individuals and institutions should, must, and can compete for support, and the pattern of support should reflect that competition. I believe that any decline in quality is likely to be a result of the introduction of the understandable political need to distribute resources by some standard of equity among regions and institutions rather than by the standard of scientific excellence. But that process can be carried out only at the cost of declining quality.

For those scientific establishments such as the national laboratories, which for good and sufficient reasons having to do with equipment costs or mission requirements are maintained on a less competitive basis, the operating institutions together with the sponsoring agency must be prepared for the most rigorous scrutiny. In the large laboratories the University of California operates for DOE we maintain a system of oversight and scientific scrutiny that we are quite confident does a good job of quality control. It has not been easy, but it is working.

Finally, I must say a word about the value of the free flow of scientific data and information that is so typical of American science. Together with the principle of competition, it is a fundamental characteristic of basic science in the United States. I am convinced that it is a necessary condition of our success. In the past year a controversy has developed within the government, and between government agencies and universities, that poses a serious threat to this scientific openness. This controversy arises from justifiable anxiety about the rapid technological advances on the part of this country's political adversaries and economic competitors. As a result, some people within the Administration have argued for stricter control of the "export", in quotation marks, of technical data. As you are aware, university based science and education is open to foreign students and scholars. And American scholars and students frequently cooperate with institutions abroad.

It is being proposed, then, that export control regulations be revised and interpreted to apply to various research activities in universities in ways that would require restrictions on persons and papers that we cannot implement or accept. We believe that to do so would so inhibit and interfere with the conduct of research and advanced teaching that its cost would far exceed any benefit in terms of slowing the advance of other nations. I believe there is a solution to this matter that would involve a reasonable mix of some security classification, some immigration control, and some good faith. I know that responsible officials are working for such a solution. I hope that political rhetoric will not destroy this process.

To sum up: I am encouraged by the Administration's avowed policy of support for scientific research, but I am concerned that in the process of cutting support for students and for research serious damage may be done to our scientific capacity. Maintaining our ability to educate the next generation of scientists and giving appropriate attention to encouraging the work of the current generation of scientists are both important. The nation needs a better and more orderly means of making science policy and planning for the future, one that is adopted to our pluralistic system. It must be capable of providing guidance on reliability of support; on the mix of basic and applied research and development; on the balance among sources of support and performers; and on the means to assure excellence and pertinence of work. The country's scientific capacity needs predictable support that provides for up to date equipment, adequate facilities, and some growth. Finally, I believe that sustained excellence in science is of the highest importance.

Thank you again for this opportunity. I hope my remarks have been helpful to the committee. I will be happy to respond to any questions.

Mr. **Fuqua**. Thank you very much, Dr. Saxon. We appreciate your testimony this morning. If it is agreeable with your time schedule, we will hear the other two witnesses. You may remain at the table, if you would like.

Dr. **Saxon**. Thank you.

Mr. **Fuqua**. Our next witness will be David Webb, vice president for policy and regulatory affairs for the Gas Research Institute.

Dave, we are happy to have you here this morning, and we will be pleased to hear your testimony. If you desire to make your statement a part of the record, it will be inserted. If you wish to summarize, that will be perfectly permissible.

[The biographical sketch of Mr. Webb follows:]

Biographical Summary

David O. Webb
Vice President
Policy and Regulatory Affairs
Gas Research Institute
1019 19th Street, N.W.
Suite 910
Washington, D.C. 20036

Education

1962	Texas Technology University B.S. in Petroleum Engineering, Mathematics Minor
1963-1965	University of Hawaii 18 credits, Business Management

Experience

September 1977 to Present	Vice President, Policy and Regulatory Affairs, Gas Research Institute. Responsible for GRI's overall operations in Washington. Primary areas of responsibility include strategic analysis and energy forecasting and coordination of GRI's interface with the Department of Energy, the Federal Energy Regulatory Commission, and other federal agencies in regard to joint programs and formulation of research policy. Provides testimony before Congress and briefings to congressional staffs on GRI's research programs.
May 1977 to September 1977	Senior Director, Energy Research Centers, U.S. Energy Research and Development Administration. Coordinated the overall program planning and research activities of the five Fossil Energy Research Centers. These five centers employed 1,100 government personnel and had an annual operating budget of $50 million.
May 1975 to May 1977	Assistant Director, Congressional Liaison for Fossil Energy, U.S. Energy Research and Development Administration. Served as the central contact for the review and coordination of all congressional activities involving the Fossil Energy Program which consisted of six line divisions with an annual budget of $800 million. Interfaced with six major committees and ten subcommittees.

STATEMENT OF DAVID WEBB, VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE WASHINGTON, D.C.

Mr. **Webb**. Thank you, Mr. Chairman and members of the committee.

I would like to request permission to insert my complete statement in the record. In recognition of the time constraints, I will try to summarize this morning, so that you can get on to the other witnesses and the questions and answers.

Mr. **Fuqua**. Thank you.

Mr. **Webb**. I am David Webb, vice president of the Gas Research Institute, which is an independent, not-for-profit, scientific research organization created by the gas industry in 1976 to plan, finance, and manage an expanded and coordinated gas-related research program for the gas industry and its ratepayers.

The Gas Research Institute does not conduct the actual research itself; it is not a Government contractor but, rather, manages and finances research conducted by research organizations. Many of these projects are cooperatively funded by the industrial performer, by Government agencies, or by State agencies.

In 1981 the Gas Research Institute funded approximately $68.5 million of gas-related research. In addition, through cooperative programs we had with other Federal agencies, our industrial performers, and some of the State agencies, we had nearly $100 million of cooperative research, for a total program of approximately $165 million.

I am pleased to appear here today, Mr. Chairman, to present my views on the need for the long-term high-risk Federal research program, and I would like to say right at the outset that much of the new emphasis on letting the market determine the introduction of new energy sources and technologies is basically sound. Also, the concept of having industry fund the near-term research and final technology demonstrations prior to commercialization, is correct, since only industry can effectively introduce new products into the marketplace.

Therefore, I think the shift in the emphasis is correct. However, I think the abrupt change from the past Federal energy research policy and the time frame in which they are trying to make the transition is too short, for the simple reason that all industries and all segments of the energy industry cannot respond in the same amount of time.

In setting R. & D. priorities and establishing your policies and funding of the Federal Government, there needs to be a recognition of the different response capabilities of the different segments of the energy industry.

Reports that the Government will essentially eliminate all fossil energy and gas-related research in fiscal year 1983, even the long-term high-risk research, is of serious concern to the gas industry and GRI. Not only is this a reversal from the stated policy of continuing to fund long-term research that industry will not fund due to market incentives, but I think it is also extremely shortsighted and not in the national interest.

Regardless of the changes that take place between now and the year 2000, fossil energy will still be delivering somewhere between

60 and 75 percent of the energy delivered in this Nation. So I do not think it is a correct focus to say that the Federal Government has no role in long-term research of fossil energy.

Also, over the past 3 years we have been very successful in reducing the level of oil imports due to fuel switching in the industrial sector primarily to gas and coal in the place of imported oil. Without a long-term research base to transition the supplemental supplies that are going to be required between now and the year 2000, there is a potential for a reversal in this very encouraging trend we have observed.

The most recent Federal projections of gas supply and demand are anywhere from 6 to 8 trillion cubic feet, or the equivalent of 4 million barrels a day, of supplemental sources of gas required to meet the demand. These supplemental sources require a technology base that is different from that of producing just conventional gas. It also involves in many cases conversion processes, which in turn take a technology base that does not heretofore exist in the traditional production of gas and its use in industry.

Before I discuss my perception on the proper Federal role in R. & D. and make recommendations in response to your request of suggestions for setting priorities for future Federal support of R. & D., I would like to outline briefly the technology status of the gas industry, a very brief history and background of how the gas industry is trying to respond to the new Federal policies, and try to use that as an illustration of why the regulated segments of the energy industry need a transition period in order to absorb much of the research the Government is proposing to drop or abandon.

The gas industry does not have in place an established, aggressive technology base with a large supporting infrastructure, yet this technology base is essential if gas is to continue to play a major role in meeting the Nation's energy demands.

Why does gas not have a major technology base in place? After the end of World War II, when the major pipeline systems and the distribution systems in this country were in place, gas was regulated and it was cheaper than other supplies of energy. The production of gas was by the oil companies, and therefore there was not a need for R. & D. We had abundant cheap supplies of energy.

Starting in the late sixties and the early seventies there was a recognition that traditional cheap supplies of gas were beginning to be depleted and that different supplemental sources of gas would have to be developed. So the gas industry's development of a technology base only started in about the late sixties or early seventies. It was very small and fragmented due to regulation at both the Federal and the State levels and due to the fact that the industry was not vertically integrated since it did not produce its own supply source.

These factors tended to limit the technology base that was in place at the start of the seventies. Naturally, these factors do not result in the best climate for aggressive investments in R. & D.

In the regulated segments of the energy industry, it is difficult enough to earn an allowed rate of return, let alone put equity earnings in further jeopardy by placing substantial investments in R.D. & D., which, if they fail, might be considered imprudent or which might be ruled as an unallowable expense.

There is no offsetting potential to increase earnings due to successful R. & D., since the benefits of successful utility research must, eventually be passed on to the ratepayers, not to the stockholders, because of the regulatory limits on rate of return. So essentially what you have is a climate that is not conducive to R.D. & D. in the industry.

The Federal Power Commission, through hearings in the early seventies, put out a rulemaking in 1976, Federal Power Commission Order No. 566, which was an accounting procedure designed to stimulate R.D. & D. by the gas and electric industries to conduct more research. The gas industry, through the assistance of the two major trade associations, the American Gas Association and the Interstate Natural Gas Association of America, responded to this incentive and established the Gas Research Institute, which was to be the research arm of the gas industry.

Part of the original charter of the Gas Research Institute, under the expanding Federal Government's role in energy policy and research funding and as required by the Federal Energy Regulatory Commission which annually reviews our application, was to coordinate our program witn that of the Federal effort. GRI has placed a high priority on coordinating our program in areas of mutual interest. We actually do much cofunding with the Department of Energy and other Federal agencies involved in energy research.

The Gas Research Institute's cofunding with Government as grown from a level of approximately $25 million in 1977 to a planned level of approximately $86 million in 1982. At the same time, the amount of coordinated funding from industrial participants in the research program has grown from a level of approximately $2.5 million in 1977 to a level of approximately $34 million in 1981. We think this is a healthy trend. We think it allows us not only to maximize the ratepayers' dollars in doing cooperative research, but it also allows us to involve, particularly in the case of manufacturing cofunding, the people who actually have to introduce the product into the marketplace.

The Reagan administration's proposed change in the philosophy and the emphasis on funding of energy R.D. & D. does cause some problems. Primarily, the Gas Research Institute and the gas industry have concentrated on cofunding with the Department of Energy.

Part of the overall program developed for the gas industry involves large amounts of cofunding. Therefore, a sudden cutback of the Department of Energy's gas-related research requires a substantial change in the strategy of the Gas Research Institute, because cofunding with DOE has been a major part of the overall scope of the program. Therefore, a change in emphasis or size of the DOE budget, whether an increase or a decrease, plays a major role not only in determining future budgets of the Gas Research Institute but also the capability to fund the technology for the gas industry.

As an example of the sudden change that is occurring, gas-related research appropriated by Congress in fiscal year 1981 was approximately $330 million. In fiscal year 1982 the amount of funds appropriated for gas-related research was approximately $158 million, or a reduction essentially of $172 million. Projections for fiscal year 1983 indicate another significant reduction in this area, perhaps to the level of only $20 million or $30 million, or essentially a termination of long-term gas-related research.

In response to these initiatives, the Gas Research Institute and the gas industry, working with our board of directors, last summer modified our strategy for cofunding with the Department of Energy and adopted the following overall guidelines for trying to determine our future budgets. Essentially, the Gas Research Institute was instructed to assume a more effective leadership role in gas-related R.D. & D., especially in the near-term research areas that were definitely in the consumer interest and could achieve a reasonable payback for the ratepayer.

We were also instructed to continue to seek cofunding with the Department of Energy on long-term research projects, and we were encouraged to increase our already extensive efforts to obtain increased cofunding from industry.

Finally, we were told to reevaluate our 1983 budget that had been submitted as part of our 5-year plan to the Federal Energy Regulatory Commission and, if necessary, to recommend to our board for proposal to the FERC in 1983 an increased and revised budget.

In response to these initiatives, the Gas Research Institute has reevaluated its 1983 budget, and instead of proposing a research budget of $107.5 million, as was projected by our 5-year plan to the FERC, we are proposing an R. & D. budget of approximately $120 million in 1983 for approval by the Federal Energy Regulatory Commission. However, it should be noted that this increase is to pick up near-term research efforts where the Department of Energy has decided to terminate programs. It does not provide the long-term research and technology base we feel will be required.

Specific increases in our 1983 program we will be proposing are in the areas of unconventional gas, where we are nearly doubling the budget from $10 million to a little over $18 million. We have proposed to increase our funding in regional and land biomass areas from $3 million to $5.6 million, and we are making significant increases in the areas of gas appliances, gas heat pumps, and onsite fuel cell systems, all of which fall in the category, we feel, of the near-term research that the industry should try to fund under the philosophy of this administration.

One additional area we are significantly increasing research funding is industrial utilization, where we think there is a tremendous opportunity to increase the efficiency of gas-using processes in the industrial sector.

However, in establishing Federal energy R.D. & D. policies, I would like to read a very brief excerpt from the Energy Research Advisory Board report on Federal energy R. & D. priorities dated November 1981. I think this is important. They have done very well in recognizing the response times of the different sectors of the energy industry.

If I could, I would read from their report at this time:

> The new policy recognizes that private industry cannot be expected to do basic energy research or projects of long-term high-risk character, but there are other circumstances in which it would be unrealistic to expect timely and effective assumption by industry of R&D responsibilities abandoned by the Government, however

> worthy the projects involved and despite the provisions of new generous tax incentives. Some of these circumstances are discussed below. Some of the markets in which energy is sold are not free. Oil and gas are the exceptions. A little over half our primary energy finds its way to consumers through the electric and gas utilities, and the utilities are regulated, price-controled industries selling their products not at free market prices but at controled prices well below replacement cost.

On further they say:

> Both these regulated industries have weak incentives to spend on R&D. If successful, the benefits go to the ratepayer. If unsuccessful, the expenditures will be disallowed as imprudent.

I think the recognition of this factor is important in determining the transitions required as the Federal Government drops research in the fossil energy areas and expects industry to pick it up.

It seems to me that the committee, in establishing energy R. & D. priorities consistent with the administration's policy of concentrating its funding on long-term high-risk research, should consider the following basic principles:

In times of constrained budgets, the research should have a national benefit, if successful. By that, I mean either the resource base or the potential of the particular process is of such a magnitude that it in fact could truly have a national impact.

Second, I think that the basic Federal policy of funding only long-term high-risk energy R. & D. must be applied consistently to all sectors. If you expect industry to respond to increase their funding for the near term, then I think there has to be a relatively even-handed approach to how you fund Federal money for research.

The benefits of the research should be such that they cannot be captured by an individual firm. If you are going to use Federal dollars to fund the research, you ought to be producing broad, generic type of information that can be applied across a broad spectrum, so the economic rate of that particular research cannot be captured by an individual firm. If it can be captured by an individual firm, it seems to me the firm ought to fund that research if it is worth doing.

The research should have significant cofunding—and by that I mean actual investment dollars—by industrial partners before any technology will be developed on the large pilot plant scale. I think part of the problem in the past with Federal funding of fossil energy research particularly is cofunding in many cases was in kind and it did not involve actual cash commitments of the industrial partner.

The unique disincentives for the regulated industries to fund R. & D. should be recognized in any transition period. If you use those principles in establishing the priorities, then my recommendations for Federal R. & D. priorities in the future would be that the Government should concentrate on long-term high-risk research.

It should continue long-term fossil energy research that is high risk and involves large resources, continue long-term generic research and efficient utilization of energy, concentrate on research that develops generic data which can be applied by a broad sector of the industry, and it ought to allocate research dollars in some relationship to the potential contribution of either the resource or the technology.

There should be an adequate transition period for industry to assume the funding of the near-term research and the midterm research that the Federal Government is dropping.

Finally, I do not think the Federal Government should fund research beyond the proof of concept, if there is a commercial potential, without industry cofunding.

I have made some specific recommendations here of what I think are legitimate long-term gas-related research areas. Primarily they are in areas such as unconventional gas resources, some of the basic rock mechanics work in the tight sands formations and the Eastern Devonian shale formations, in-situ coal gasification and geopressured methane where the resource is primarily on Federal lands. It is very long-term and high-risk but at the same time, if successful, could alter, the resource balance in this country to the point that it could have a national impact.

The total program I have recommended and laid out is approximately $100 million. While this is a significant amount of funding, it is much less than the gas industry has increased its funding over the next 2 years to pick up the near-term research. At the same time, it is approximately $60 million less than what was actually appropriated in fiscal year 1982, and it is only one-third of the level appropriated by Congress in 1981. Consistent with the long-term nature and with the need to recognize curtailment of Federal expenditures, I think it is consistent.

One other recommendation I might make, that you asked me to try to comment on, is for stabilizing energy R. & D. planning and the budgeting process, so industry and the universities can react to the switch in policy.

My first recommendation would be to expand and continue congressional hearings such as the one we are having here today, so the debate and the recognition of the different industries' needs is handled through congressional hearings and not through the budget process.

Second, it seems to me that if Congress, working with the Federal Government, could develop program costs rather than annual costs of major energy programs, then you could debate the merits of the program with the full knowledge of the cost and future mortgages. That would tend to say if you approve a 7-year program, and the costs have been laid out and debated, then industry pretty well has an idea of the magnitude of the funding the Government is committing over the life of that program. Also, research managers can set their programs and schedules without trying to adjust to tremendous differences in funding on an annual basis as we try to whip the energy program in line with the budget needs or the deficit needs.

I think you should consider some kind of total program authorizations for some of these major energy programs. Then it seems to me you could conduct oversight hearings on either an annual or biennual basis to verify the original objectives of the program and that milestones are being met, so you know whether the program should be allowed to continue. If technical problems have occurred, or the technology no longer has promise, then the program could be terminated.

Finally, I think the encouragement of multiyear appropriations—I do not know whether we are talking 2- or 3-year appropriations, but multiyear appropriations to add some stability to the process would help.

In summary, Mr. Chairman, I just want to say I think there needs to be a recognition that the regulated segments of the energy industry have a different capability and need a different amount of time to respond to the changing Federal policy.

I think you will find the industry willing to increase its funding. As I said, the gas industry, through GRI, is talking about significant increases in funding in 1982 and 1983. At the same time, the amount of dollars involved will not cover picking up the near-term research projects the Federal Government is dropping and, at the same time, pick up the long-term research that it appears they are abandoning at this time.

One final comment, if I could. It does not have anything to do with the gas industry, but I would just like to echo the previous witness's statement. I think our Nation's universities, especially at the graduate school level, are seriously impacted by funding uncertainties. In selecting a research topic for a thesis, the master's or doctoral candidate must be reasonably certain that the period of funding will last long enough for him to complete his dissertation.

So I think constantly changing policies tend to discourage some of the brightest and best graduate students from applying their knowledge and energy to solving some of this Nation's energy problems. I would hope this committee would encourage DOE and the Government to be especially sensitive to the vulnerability of our universities and our graduate students in considering the impact of the funding reductions they are talking about.

That concludes my testimony, Mr. Chairman. I thank you and the committee members very much for the opportunity to appear here. At the appropriate time, I would be glad to try to respond to any questions you may have.

[The prepared statement of Mr. Webb follows:]

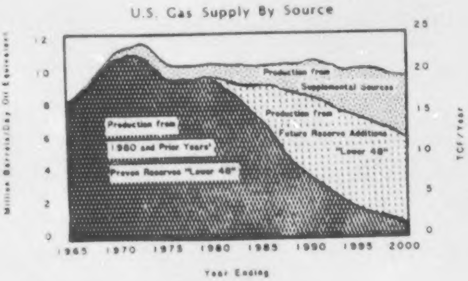
STATEMENT OF DAVID O. WEBB, VICE PRESIDENT
GAS RESEARCH INSTITUTE
BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
OF THE UNITED STATES HOUSE OF REPRESENTATIVES
FEBRUARY 2, 1982

Mr. Chairman and Members of the Committee:

I am David Webb, Vice President of the Gas Research Institute (GRI), an independent, not-for-profit scientific research organization created by the gas industry in 1976 to plan, finance, and manage an expanded and coordinated gas-related research and development (R&D) program for the mutual benefit of the gas industry and its ratepayers. GRI conducts no R&D work itself; it contracts with other organizations to conduct research projects. Many of these projects are cooperatively funded by the industrial performer, government agencies, or state agencies. GRI became fully operational in 1978, and today its membership consists of 197 investor-owned and publicly owned companies which transport and distribute gas in interstate and intrastate commerce. In 1982 GRI will fund approximately $84 million of gas-related research which is a significant increase over the 1981 research budget of $68 million. Additionally, approximately $100 million of federal and industrial cooperative funds were obtained in 1981 for a total coordinated program of $165 million. GRI plans to increase its funding of near-term research in 1983 by seeking approval of an R&D budget of approximately $120 million, again a major increase of $36 million over the approved 1982 research budget. However, based on recent projections of significantly reduced federal funding for gas research, the amount of coordinated funding will actually decline despite the GRI growth.

I am pleased to appear before you today to discuss my views on the continuing need for a long-term, high-risk federal research program on supplemental gas supplies and more efficient utilization of gas by end-users. Let me say right at the outset that much of the new emphasis on letting the market determine the introduction of new energy sources and technologies is basically sound. Also, the concept of having industry fund the near-term research and final technology demonstrations prior to commercialization is the correct approach since only industry can effectively introduce new products into the market. The shift in emphasis is correct, but it is such an abrupt change from past federal energy research policy that it will require an orderly transition if critical research projects are to continue under industry sponsorship.

Therefore, reports that the government will essentially eliminate all fossil energy and gas-related research in FY 1983, even long-term, high-risk research, is of serious concern to the gas industry and GRI. Not only would this be a reversal of the government's stated policy of continuing to fund long-term research that industry will not fund due to [illegible]rket incentives, but it also would be extremely shortsighted and not in the national interest. As an illustration of the potential national impact of such a policy which fails to provide the resources necessary for a long-term gas technology base, consider that all major federal projections of future gas supply and demand predict a requirement of between 6 and 12 trillion cubic feet (Tcf) of supplemental sources of gas to meet projected demand in the year 2000 as shown on the following page. The timely and effective development of these supplemental sources requires a viable and stable federal presence in long-term gas research. Since gas currently supplies over 12 Tcf of energy to the industrial and power generation sectors, without an adequate long-term technology base necessary to develop cost-effective supply sources of gas, the probability of fuel switching is very large. The magnitude of fuel switching could result in a large increase in oil imports of between three to five million barrels per day. Therefore, there is a dominant national issue in determining the proper federal energy policy in gas-related research to ensure continued reduction in oil imports.



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Before I discuss my perception of the proper federal role in R&D and make recommendations on how to set priorities for direct federal support of R&D and how to provide a greater measure of stability to the R&D planning and budgeting process, I would like to outline the major technology base needs of the gas industry, the current status of the funding of a gas technology base, and the gas industry response to the new shift in federal energy policy. This background is important in understanding and determining the proper federal R&D priorities and policy.

Technology Needs of Gas Industry

The key element to consider in determining gas technology needs--and hence future R&D directions--is the shrinking cost advantage of natural gas relative to competitive energy sources--primarily electricity and oil. In the simplest terms, this changing condition makes it imperative to improve gas end-use efficiencies in ways which take advantage of the superior characteristics of methane as a fuel. Improved technology is also needed to minimize rising equipment costs and to develop new sources of methane at the lowest cost.

The best answer to rising energy costs and the shrinking cost advantage of gas is a strong technological response. No one wants continuation of externally imposed market distortions, be they in favor of gas, electricity, oil, coal, or renewables. First and foremost among needed technological responses is the development of end-use appliances and equipment that would allow gas to compete with other energy forms on the basis of the total energy service cost to the user. This means head-to-head competition of gas with electricity, oil, and coal in a myriad of residential, commercial, and industrial applications.

In the longer term, as larger proportions of gas supply come from new and increasingly costly supplemental sources, the whole infrastructure of energy end-use may change. The major issue will be total electrification versus continued direct use of gas, oil, and coal. A critical subissue will be electrification via central station power supply, presumably coal- and nuclear-fueled, versus electrification via decentralized cogeneration systems. If the latter should gain an economic advantage, gaseous fuels could again play a central role because of the relative ease of transporting, storing, and using them in an environmentally acceptable fashion. This, then, may be the era of fuel cells, advanced combined-cycle systems, and all the other technologies which so greatly enhance the efficiency of energy conversion and use by providing both electricity or shaft horsepower and heat on site.

My view, then, of important R&D directions and needs in gas R&D begins with near-term developments in efficient utilization. Without improved gas efficiency in highly competitive markets, the consumer cannot benefit from an appliance that often costs more unless it offers fuel or cost-of-operation saving over a comparable electric model.

EFFICIENT UTILIZATION

In the residential/commercial gas market, the major factor that drives the need for improved technology is the ratio of delivered electricity prices to delivered gas prices on an equivalent Btu basis. Today, the ratio is approximately 4:1 on a national average, but it could fall to about 2:1 by the year 2000. Given this, a conventional gas furnace with electric air conditioning would lose its competitive price advantage to a standard electric heat pump sometime between 1985 and 1990 in many regions of the U.S.

As far as the industrial gas market is concerned, security of supply, as well as competitive energy prices and the actual cost of the delivered energy services, are the critical factors in assessing the future role of gas and in determining the need for new, more efficient end-use technologies. Several price projections for the industrial energy market still seem to favor gas over residual oil. However, an excessive flyup of natural gas wellhead prices upon decontrol, even over a limited period while unrealistic contract provisions are being renegotiated, could lead to permanent displacement of gas with imported oil in relatively low-technology heat energy applications.

I have emphasized the end-use of gas up to this point; it is because of the necessity, in the short term, of providing least service cost options to consumers in a critical period of escalating gas prices.

I will not ignore the supply side of gas R&D; in fact, it is critical to understanding the directions and needs of gas R&D overall and the proper federal role.

Among the many gas supply options, several show special promise to overcome competitive energy service cost pressures. For example, the costs and quantities of unconventional gas produced from tight formations, Devonian shales, and coal seams are so highly technology dependent that they provide some of the most attractive targets for R&D initiatives. Coal gasificaton is, of course, the major mid- to long-term supply option. However, the underlying technology base for coal gasification is quite mature so that new R&D opportunities must concentrate on novel approaches and basic research in catalysts and materials.

GAS SUPPLY IN THE LONG RANGE

The picture is quite different for the longer range. Key targets for major R&D investments are land- and marine-based biomass production and conversion. Not only is biomass a credible option for long-term energy supply throughout the world, it is also a critical hedge technology in case the coal option cannot be fully exploited because of the carbon dioxide problem and in case the nuclear option continues to falter because of socio-political, operational, or economic reasons. Our own recent experience with the agricultural industry of Florida points to the possibility of rotation of food and energy crops and other schemes that do not compromise food production. The potential of biomass R&D is staggering when one considers the work still to be done in hybrids and genetic engineering, let alone in the agricultural sciences, and on the economic development of anaerobic digestion technology.

Still farther into the future lies the possibility of nearly endless supplies of methane from deep in the earth. If Thomas Gold and others who are measuring the occurrence and magnitude of methane seeps from tectonic faults are correct, there may be enormous amounts of methane still available to us as a legacy from the earth's creation. Very few geologists now deny the existence of abiogenic methane; the issues are its quantity and economic recovery. The implications of this hypothesis, however, are so enormous for the long-term supply of gas that the theory needs to be validated or disproved. Investigations of equally long-range technologies in methane and heat energy recovery from geopressured brines, recovery of methane from widespread hydrate deposits, and water decomposition to hydrogen by thermal and photochemical means should be coupled with these studies.

This illustrates that the issue is not determing legitimate areas of long-term, high-risk, gas-related research. Rather the problem is to define the proper federal long-term R&D role and to stabilize planning and funding so that the gas industry can concentrate on funding and managing an expanded research program in near-term research as a true partner with government.

History of Gas Industry Technology Base

The gas industry does not have in place an established aggressive technology base with a large supporting infrastructure. Yet this technology base is essential if gas is to continue to play a major role in meeting the nation's energy demand. The uncertainty of the impact of gas-producer price deregulation; the gas transmission and distribution industry's lack of control over the quantity and price of gas, the continuing imbalance of electric versus non-electric government funding of R&D, the limited gas R&D marketing efforts by large manufacturers of energy service equipment, and the recent sharp drop in federal gas R&D represent significant impediments to establishing the technology base required for the most effective use of gas in the U.S. energy mix. A wide range of gas industry responses will be necessary. The gas industry has begun an aggressive R&D program, but it is still behind its competitors in the development of a sound technology base.

HISTORY OF GAS R&D

A brief review of the history that has led to this situation is instructive in determining the proper federal role in developing a sound technology base for gas. After the growth of interstate pipeline systems made natural gas available in nearly all parts of the United States following World War II, the gas industry had relatively little need to invest in R&D. Supply was ample and underpriced in comparison to most competitive energy sources and was largely the responsibility of entities not part of the regulated transmission and distribution segments of the gas industry. The major technological issues falling under the jurisdiction of these regulated segments concerned peak load supply and seasonal storage; a number of problems concerning the cost, efficiency, reliability, and safety of distribution and transmission operations; and the safety of gas-using equipment and appliances. A total of only something on the order of 0.1 percent of gross revenues was spent by the transmission and distribution companies for R&D in these areas and on a few longer range supply and utilization options such as coal gasification, hydrogen, and fuel cells. As electric competition in the residential/commercial market grew, the gas industry began to recognize the need for a greatly expanded technology base.

However, compared to its major competitors, the petroleum and electric industries, the gas industry had limited resources and capabilities to respond rapidly to this challenge. Multilayered regulation, the relatively small size of individual corporate units, and the differing interests of the generally independent production, transmission and distribution segments limited the business incentives and opportunities for major R&D investments. Moreover, federal subsidies available for development and commercialization of new gas technologies in the form of research, development and demonstration (RD&D) conducted in government facilities or sponsored by government agencies, and in the form of grants and other financial incentives funded through general revenues, were small when compared to those available to other energy sectors. And finally, unlike their electric utility counterparts, the gas companies lacked the support of the many manufacturers--including such integrated giants as General Electric and Westinghouse--which devote most or all of their activities to electric products. The result was the limited ability and resources to rapidly construct the research necessary to create an adequate gas technology base for the reasons outlined above and summarized below.

TECHNOLOGY BASE DEVELOPMENT CAPABILITY

	Petroleum	Electric	Natural Gas
Vertical Integration	Yes	Yes	No
Impact of Supply Deregulation	Very Positive	Possible Threat	Very Negative
Technical Capability	Very Strong	Strong	Limited
Internal R&D Funding Capability	Excellent- Large Corporate Units High Returns Large Tax Credits	Limited By Regulation	Severely Limited by Multilayered Regulation
Manufacturer Support	Very Large- Transportation (with DOD) Chemicals Most End Uses	Very Large- Most Supply & All End Uses (G.E. Westinghouse, etc.)	Limited
Federal RD&D Support	Very Little	Very Large- DOE, TVA	Very Little
Federal Commercialization Support	Limited - SFC	Very Large- Nuclear	Some - SFC Negative impact from Great Plains Decision

While the gas industry had conducted a small research program under the direction of the American Gas Association (A.G.A.), it was not of the magnitude necessary to fund the multitude of research projects essential to develop cost-effective supplemental sources of gas and more efficient gas equipment and processes. The A.G.A. research program was initiated in 1943 and expanded in 1963. In the following ten-year period, annual research expenditures grew from $3 million to approximately $10 million. In 1971, the A.G.A. and the Department of Interior's Office of Coal Research started a cooperative effort to accelerate the development of coal gasification. This pilot plant R&D program was funded at an annual budget level of $30 million--two-thirds from the government, one-third from industry. Thus, the gas industry had a very small institutional R&D program in existence with total annual expenditures of about $20 million by 1975. This is a stark contrast to the approximately $1 billion in annual federal funds devoted to R&D for nuclear and other long-term electric options during this time. Essentially the lack of a large and viable gas industry technology base primarily results from the following factors:

- Until the early 1970s, natural gas was in abundant supply and the required production research was conducted by the nonregulated petroleum industry.
- Regulation of gas prices at the wellhead resulted in gas being a cheap energy commodity; therefore, there was no emphasis on efficient utilization.
- Since gas was cheaper than other competing energy sources, the emphasis for end-use appliances and processes was lowest cost, not efficient or low life cycle costs. This greatly reduced the need for a strong technology base.
- There was a strong federal preference and a long history of federal funding of a large R&D program for electric options. No similar program existed for the gas options.
- There was a lack of recognition by the state regulatory agencies of the need for the gas utilities to fund an expanded gas industry technology base.

o Since the recovery of costs incurred in funding gas industry R&D must be approved by the state commissions, the regulatory mechanism of controlling the total rate of return on invested capital that is used and useful in public service inhibited funding of a strong gas technology base.

Naturally, these factors do not result in the best climate for aggressive investments in R&D. It is difficult enough for regulated companies to earn their allowed rate of return let alone put equity earnings in further jeopardy by placing substantial investments in RD&D which, if they fail, might be considered to have been imprudent or which might not be ruled an allowable expense for other reasons. Therefore, RD&D investments make little management sense. There is no offsetting potential to increase earnings due to successful RD&D as there would be for unregulated companies. The benefits of successful utility RD&D must eventually be passed on to the ratepayers, not the stockholders, because of the regulatory limits on rates of return.

Despite these disincentives, in response to a growing recognition of the critical need for a strong technology base to meet increasing competition from electricity and to relieve gas supply shortages and curtailments in the early 1970s and a more favorable federal regulatory climate, the gas industry took initial steps in 1972 to dramatically increase institutional funding of gas-related research.

Gas Industry Response to Technology Need

In late 1972, the A.G.A. research management staff and research committees, in cooperation with the Interstate Natural Gas Association of America (INGAA), organized and directed a comprehensive study of gas industry research needs and opportunities for the period of 1974-2000. A 150-person industry-wide task force and six prominent research agencies completed the study during 1973. The recommendations which evolved from this planning study led to the conclusion that a more comprehensive and expanded gas-related research program would be required if gas were to continue to play a major role in meeting the future needs of the U.S. economy.

While the need for an improved gas technology base was readily recognized by industry leaders and many farsighted regulators, the gas industry faced considerable obstacles in funding an aggressive R&D program. As noted before, regulated transmission and distribution companies had traditionally spent a relatively small percentage of their gross revenues on RD&D. Since the benefits of successful utility RD&D must eventually be passed on to the ratepayers, not the stockholders, a mechanism had to be found to allow recovery of the costs of research from the ratepayers.

FORMATION OF GRI

To overcome the dilemma of the obvious need for more gas utility RD&D and the difficulty in funding an expanded utility RD&D program through conventional means, the Federal Power Commission (FPC) issued an order (No. 566) designed to stimulate RD&D by companies under FPC jurisdiction. It provided for preapproval, not subject to refund or reduction, of RD&D expenditures of jurisdictional companies that met clearly delineated guidelines which not only protected the ratepayer interest but also set such high standards for R&D planning, coordination, and evaluation that the need for detailed regulatory review could be minimized. This imaginative concept of the FPC for stimulating cooperative industry RD&D programs was implemented by the gas industry in 1976 by the formation of GRI with the assistance of the gas industry's two major trade associations, A.G.A. and INGAA.

The issue of prudence of major RD&D investments was largely defused by introducing centralized, highly sophisticated planning and analysis; careful coordination with other major energy RD&D programs, including that of GRI's older and significantly larger sister institution, the Electric Power Research Institute (EPRI), the extensive joint efforts with the Energy Research and Development Administration (ERDA) and then the Department of Energy (DOE); and bringing into the decision-making processes consumer and other public-interest representatives. Prominent among these representatives is a substantial number of sitting state regulators and several eminent educators, environmentalists, and former federal regulators. GRI thus became the agent for financing, planning, and managing the R&D of its 29 interstate pipeline members which are responsible for more than 95 percent of all interstate gas sales.

However, because of the limited vertical integration of the regulated gas industry, a mechanism also had to be developed for sharing control in the management of GRI between the interstate pipeline transmission companies, which were responsible for collecting the preponderance of the funds under Federal Energy Regulatory Commission (FERC) jurisdiction, and the distribution companies which had to pass through these charges as part of their purchased gas costs to their ratepayers under state commission jurisdiction. Of course, even more fundamental in this shared control over the affairs of GRI was the makeup of its R&D program. It had to properly reflect not only the ultimate ratepayer interest, but also the often quite different interests of the transmission and distribution segments of the industry. The solution was found in having board representation of these two segments, including assured minimum representation of the municipal distribution companies, i.e., the many usually relatively small companies owned by local governmental bodies. Thus GRI was created as the central element in the gas industry's response to the need for a viable technology base.

History of GRI/DOE Research Coordination

In its review of GRI's application, the FERC places a high priority on the coordination of GRI's program with government and industry R&D programs. GRI must annually provide "...evidence that an effective mechanism exists and is used for coordinating this research and development plan with other relevant efforts of national scope."

While the Commission's coordination directive was broad, it recognized that DOE "is the principal organization with which GRI's program must be harmonized." GRI placed a high priority on coordinating and, in areas of mutual interest, on cofunding research projects with DOE and other federal agencies. GRI adopted a deliberate strategy to stretch GRI's limited funds by cofunding or cooperatively funding projects of common interest with DOE and other government agencies. This allows GRI to attain greater R&D benefits per ratepayer dollar than if it funded the entire project on its own.

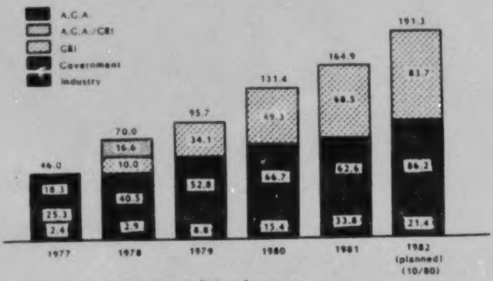
By placing a high priority on coordination, GRI aimed not only to meet the FERC requirement to coordinate its research with the national effort to eliminate the duplication of research efforts but also sought to focus the attention and financial resources of other funding organizations on the research needs of the gas industry. The importance of working to expand existing R&D efforts rather than to absorb them was reemphasized by the Commission:

> . . . we put GRI on notice that as its program matures we shall insist on clear evidence that its efforts are complementary to and not competitive with those of other RD&D organizations.

GRI was highly successful in attaining cosponsorship of gas-related research. From the creation of GRI to 1981, the size of government and industry cosponsorship grew substantially. This effort resulted in a combined government and industry coordinated funding level of $96.4 million in 1981.

This funding, when combined with GRI funding for contract R&D, amounted to a national gas R&D program of $164.9 million in 1981. This was supplemented by approximately $40 million of research funding by individual gas companies to address issues unique to their service area.

GRI COORDINATED FUNDING HISTORY
($ Millions)



Note: State cofunding shown in "Industry" category.

DOE and GRI have cosponsored research in fuel cells, biomass, industrial utilization, heat pumps, unconventional natural gas, geopressured methane, in-situ coal gasification, and environmental research. In addition, DOE and GRI have continued the jointly sponsored coal gasification program that began in 1971 as a cooperative effort of A.G.A. and the Office of Coal Research. The total funding under the joint coal gasification program through 1981 has been $187 million, of which the gas industry has provided one-third and the government has provided two-thirds.

Much of the effectiveness of GRI's program during the first five years depended on expanding GRI's limited funds with DOE funds on projects of common interest. While this stimulated more cooperatively funded gas-related R&D and allowed GRI to gain exceptionally high benefits from its R&D investments, it also resulted in GRI following DOE's lead in most long-term technologies.

with significant federal R&D expenditures, GRI was able to rely on DOE to fund the critical mass of funds necessary to support a research program. GRI was able to concentrate its funds on expanding projects or programs to meet the specific needs of the regulated gas industry and the gas ratepayer.

In many instances, the very large entry costs in a given R&D area were properly borne by the government, while the much lower costs of subsequent research activities were borne by GRI. For instance, in geopressured methane gas research the cost of drilling experimental wells would be borne by the government while GRI would pay for subsequent research activities, such as the diagnostics and analytical evaluation during and following well stimulation.

The major impact on the success of GRI's cofunding strategy was the dominant importance of energy and national energy policy during the 1970's. Federal energy functions were consolidated into a cabinet-level Department of Energy, federal energy budgets soared, and, most importantly, the government assumed the major responsiblity for determining the nation's energy future. National energy plans were prepared; targets for the commercialization of technologies were set; and production goals were specified for a variety of fuels. As Secretary Duncan testified in January 1980 before the House Committee on Science and Technology: "The Department of Energy sees its mission as assuring the Nation's orderly transition from an economy dependent upon oil to an economy relying upon diversified energy sources."

While the private sector retained its traditional responsibility for commercializing technologies, the government believed there were overriding national concerns that required the federal government to intercede in the marketplace. As Secretary Duncan noted, "...energy, and particularly our dependence on foreign oil, has more to do today with our inflation rate, the value of the dollar, and our balance of payments deficit than any other component."

With the election of President Reagan, the philosophy of the government's role in energy shifted significantly. The government forsook the responsibility for determining whether and when technologies would enter the marketplace and delegated the responsibility for determining the future energy mix to the private sector. The Administration believes, "The collective judgment of properly motivated technical innovations, businessmen, and consumers is generally superior to any form of centralized programming." The Administration asserted that its most direct role was to bring the enormous energy resources controlled by the government into the energy marketplace.

Effects of Changing Federal Policy on Gas-Related R&D

The Reagan Administration has proposed to radically change the size of the federal energy research budget and to encourage industry to fund more of its own research, especially near- and mid-term projects. This policy is summarized in the President's National Energy Policy Plan as follows:

> Public spending for energy-related purposes is secondary to ensuring that the private sector can respond to market realities. Even then, federal spending should be considered only in those promising areas of energy production and use where the private sector is unlikely to invest.... Public spending is appropriate (and will continue) in long-term research with high risks, but potentially high payoffs. In most cases, however, using public funds to subsidize either domestic energy production or conservation buys little additional security and only diverts capital, workers, and initiative from uses that contribute more to society and the economy.

From its inception, GRI, in response to FERC guidance and encouragement by DOE, has relied on extensive federal and industrial cofunding to carry out its research programs. The federal government's current R&D policy emphasizes long-term, high-risk projects with major reductions in near- and mid-term R&D. This philosophy has resulted in rapid, substantial cuts in DOE's RD&D budget and further planned cuts based on the assumption that DOE or its successor agencies will concentrate on the long-term, high-risk research that industry will not perform in response to normal market incentives.

The impact of the new federal energy policy on GRI and gas-related research is readily apparent in the change in the size and distribution of federal gas-related R&D budgets. The federal budget for energy RD&D and gas-related research grew dramatically over the past seven years. The revised FY 1982 DOE budget clearly illustrates that this trend has changed.

Most of the DOE gas-related R&D is funded through the Fossil Energy program and the impact of the new philosophy and funding strategy seriously reduced these efforts as shown below.

DOE Fossil Energy Gas-Related
Research Budget
($ Millions)

Technology Area	Carter 1981 Budget	Reagan Revised 1982 Budget
Advanced Research and Technology Development	$14.5	$12.5
Phosphoric Acid Fuel Cells	14.0	10.6
Underground Coal Gasification	10.0	8.6
Surface Coal Gasification	159.9	54.0
Enhanced Gas Recovery	30.6	10.6
Total	$229.0	$96.3

When the remaining gas-related activities of the Department are added, the net effect is that DOE requested $162 million less in FY 1982 for gas-related activities than the Congress appropriated in FY 1981.

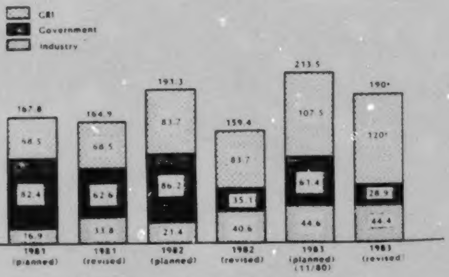
DOE GAS-RELATED BUDGET
($ Millions)

	FY 1981 Appropriation	FY 1982 Revised Request	Change
Fossil Energy	229.0	96.3	-132.7
Geopressured Methane	36.0	20.2	- 15.8
Energy Conservation	22.0	12.0	- 10.0
Biomass	12.5	3.0	- 9.5
Basic Research	27.0	30.0	+ 3.0
Environment & Safety	31.0	34.0	+ 3.0
Total	357.5	195.5	-162.0

The sudden cutback of DOE gas-related RD&D required a substantial change in the R&D strategy of GRI because the level of funding by DOE for gas-related research has a major impact on the scope and size of the GRI program. When the size or the trend of the DOE budgets in these areas suddenly makes a significant shift (either increase or decrease), it plays a major role in determining future GRI budget levels. While GRI is not cofunding all of these research areas, if there were no government funds, GRI would have to consider funding some of these research projects since they support GRI objectives and are an integral part of GRI R&D strategy and the development of an adequate gas technology base. Without the DOE funds, research efforts in cofunded efforts such as on-site fuel cells, unconventional natural gas, heat pumps, coal gasification, and gas from biomass would be either drastically curtailed and research milestones slipped or else GRI's budget would have to be increased significantly in these areas while other research areas of a long-term nature would have to be cancelled.

GRI revised its projections for coordinated funding to reflect the decrease in federal cofunding and accelerated its efforts to obtain industrial cofunding. While GRI originally anticipated $82.4 million in federal cofunding in 1981, this projection was revised to $62.6 million. However, a substantial increase in industrial cofunding nearly eliminated the drops in federal funding. In 1982, coordinated funding is expected to drop by $31.9 million in spite of an expected increase of $19.2 million in industrial coordinated funding. Based on the DOE FY 1982 gas-related budget and policy to continue funding in long-term, high-risk research, GRI expects coordinated funding to drop to $28.9 million or even lower in 1983. How much lower coordinated funding levels drop will depend upon the degree to which the Administration moves to eliminate the remaining near-term activities and to eliminate or significantly reduce its sponsorship of long-range, gas-related technology development.

REVISED GRI COORDINATED FUNDING PROJECTIONS ($ MILLIONS)



Note: State cofunding shown in "Industry" category

The Administration is expected to request a budget that would essentially eliminate DOE's sponsorship of conservation R&D and confine the Department's involvement in solar energy to a technology base program for long-term options. The Administration is expected to request an FY 1983 budget for Fossil Energy that is reduced roughly by 75 percent from the budget it requested for these activities in FY 1982.

The expected FY 1983 DOE budget request would severely impact major current DOE/GRI joint programs as can be seen from the chart below:

POSSIBLE FY 1983 DOE FUNDING IMPACT
ON MAJOR DOE/GRI JOINT PROGRAMS

Unconventional Natural Gas	DOE Program Terminated
Geopressured Methane	DOE Program Terminated
Underground Coal Gasification R&D	DOE Program Terminated
On-Site Fuel Cells R&D	DOE Program Terminated
Gas Heat Pumps	DOE Program Terminated
Methane from Biomass	DOE Program Terminated
Surface Coal Gasification	DOE Funding Severely Limited

GRI Response to Revised Federal R&D Policy

In reaction to the change in government R&D funding policy, GRI discussed a variety of options with its Board of Directors and adopted the following strategy:

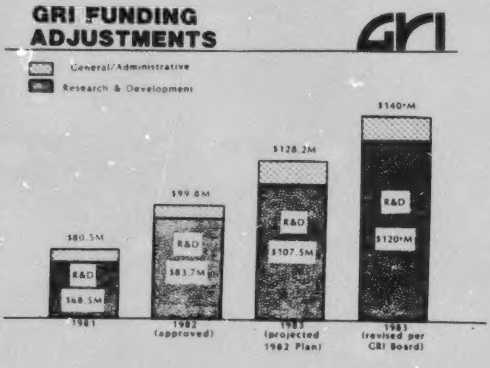
- GRI should assume a more effective leadership role in gas-related R&D. As the level of federal funding and support declines, GRI must become more aggressive in assuring that critical research is continued at adequate funding levels. Essential near-term research must be funded by GRI if it is in the consumer interest.

- GRI should continue to seek cofunding with DOE in long-term research projects. In determining whether to cofund a project with DOE, GRI should give consideration to the relative size of the DOE contribution and to the long-term commitment by DOE. GRI should carefully assess DOE's program goals and objectives before entering into any joint program to make sure that they are consistent with goals and objectives of GRI.

- GRI should increase its already extensive efforts to obtain increased cofunding from industry. This not only provides a partial substitute for government support, it also improves the prospects for commercialization. This substitution is already underway to compensate in part for the loss of about $20 million in expected government funding for calendar year 1981.

- GRI should reevaluate its projected 1983 budget in light of the significant changes in national energy R&D policy. An expanded budget should be prepared if necessary to make sure that sufficient funds are available to achieve the objectives of the GRI R&D strategy.

In keeping with these directives, and in recognition of the changed federal policy, GRI has reevaluated its 1983 research budget and is proposing to increase that budget from $107.5 million, which was originally planned and projected in its application to the FERC for the 1982 program, to approximately $120 million to meet the continuing critical need for near- and mid-term research.



As shown below, this proposed budget growth will continue the emphasis of industry funding for near-term efficient utilization programs in recognition of the Administration's policy of terminating this research and concentrating its resources on long-term, high-risk research.

GRI R&D BUDGET SUMMARY ($ Millions)

	1982	Proposed 1983
Total R&D	$ 83.7	$118.6
Program Area		
Supply	$ 26.4 (31.5%)	$ 33.1 (27.9%)
Environment, Safety, and Distribution	$ 10.6 (12.6%)	$ 14.7 (12.4%)
Efficient Utilization	$ 36.0 (43%)	$ 57.2 (48.2%)

Note: Percentage figures indicate share of total R&D budget

This funding strategy has been devised in an attempt to save critical projects from elimination while, at the same time, fulfilling the gas industry's near-term technology needs.

Specific GRI programs where funding increases will be concentrated to offset the loss of DOE funding are in the areas of unconventional gas, regional and land biomass, on-site fuel cells, gas appliances, gas heat pumps and industrial utilization.

GRI NEAR-TERM BUDGET INCREASES ($ Millions)

	Approved Budget 1982	Proposed Budget 1983
Unconventional Gas	$10.60	$18.70
Regional and Land Biomass	2.90	5.65
On-Site Fuel Cells	11.35	19.60
Gas Heat Pumps	7.00	12.10
Gas Appliances	3.97	6.50
Industrial Utilization	7.90	12.15
	$43.72	$74.70

Proposed 1983 Budget Increase = $30.98

Increases in funding for unconventional natural gas will be focused in two areas--blanket tight gas sands and Devonian shales.

In the biomass area, additional funding will be applied to near-term research, much of which is being carried out by the University of Florida's Institute for Food and Agricultural Sciences (IFAS) under a joint GRI-IFAS program.

Increased funding for development of fuel cells will be used to support the on-site fuel cell field test program which GRI had been jointly funding with DOE.

In the heat pump area, GRI funding will be directed at picking up work previously supported by DOE.

Industrial utilization programs will receive additional emphasis with increased funding in several project areas including cogeneration, development of ceramic fiber insulation, and R&D on advanced burner systems.

This proposed increase in GRI 1983 funding will only be sufficient to fill the gap in near-term gas-related research left due to the severe reductions in federal spending. Therefore, it is essential that the federal government maintains an adequate long-term research program to support the gas industry's technology base.

The gas industry, in the face of this shift in federal energy policy and growing competitive pressures, must be assured of the availability of a gas technology base to continue to be able to offer reliable service to U.S. gas consumers at the lowest possible cost.

Establishing Federal Energy R&D Priorities

During the past eighteen months, the perception of the federal role in the support and funding of energy R&D has drastically changed.

OLD FEDERAL R&D POLICY

Essentially, the past federal policy consisted of the following points:

- Rapidly expanded energy research budgets in all sectors,
- Funding of major pilot plant and demonstration plants in fossil fuels,
- Significant research in near-term energy supply and utilization technologies,
- Assisting industry in the commercialization of new technologies, and
- Policies designed to reduce the nation's vunerability to oil imports.

NEW FEDERAL POLICY

Now, the new policy is based on the following points:

- Rapid reduction of non-nuclear energy research budgets,
- Drastic reduction in funding of all near-term energy R&D except nuclear energy,
- Abrupt shifting of the sponsorship of near-term R&D to the private sector,
- Elimination of the federal funding of technology demonstrations,
- Elimination of assistance to industry in commercialization of new technologies,
- Rejection of national planning to reduce the nation's vulnerability to oil imports, and
- Focusing the federal funding of energy R&D on long-term, high-risk projects.

Such an abrupt change in policy must recognize the following factors if it is to be effective and supported by industry:

- The policy must be applied fairly to all sectors of the energy industry to prevent market distortions.
- The difference in response time required to increase funding for near-term technology for different sectors of the energy industry must be recognized.
- The current status and funding of the technology base of different sectors of the industry are different.
- Past federal R&D policies and funding levels have already created distortions in the ability of different sectors of the economy to respond to the new energy R&D policy.
- The ability of the regulated energy sectors to capture the economic rent accompanying free market pricing of energy is severely limited compared to the unregulated oil and coal companies.

The Energy Research Advisory Board (ERAB) put these factors in proper perspective in its report Federal Energy R&D Priorities dated November 1981.

> We applaud greater reliance on the private sector whenever possible. We applaud the restoration of a free market in petroleum. ERAB believes that much, perhaps most, of new energy supplies and greater efficiency in energy use will

in fact be achieved by higher energy prices. But ERAB is concerned that some energy R&D of great potential significance for the achievement of the Nation's energy goals will fall between federal and industry responsibilities.

The new policy recognizes that private industry cannot be expected to do basic energy research or projects of long-term, higher risk character. But there are other circumstances in which it would be unrealistic to expect timely and effective assumption by industry of R&D responsibilities abdicated by the government, however worthy the projects involved, and despite the provision of new generous tax incentive. Some of these circumstances are discussed below.

Some of the markets on which energy is sold are not "free." Oil and coal are the exceptions. A little over half our primary energy finds its way to consumers through the electric and gas utilities, and the utilities are regulated, price-controlled industries, selling their products not at free market prices, but at controlled prices well below replacement cost.* The consequences are that consumers of gas and electricity have less of an incentive to conserve (and, therefore, to undertake research on conservation) and that producers of electricity are so strapped financially that they cannot afford conventional additions to capacity, let alone demonstration projects or any expensive R&D. Gas producers are faring somewhat better and can look forward to eventual decontrol at the wellhead, but gas transmission and distribution will remain under control indefinitely and so presumably will the investor-owned electric utilities.

Both these regulated industries have weak incentives to spend on R&D. If successful, the benefits go to ratepayers; if unsuccessful, the expenditure may be disallowed as "imprudent."* In the case of electricity (but not gas), a substantial amount of R&D has been undertaken by large research-oriented equipment suppliers. And during the past decade the "invention" of a device for financing industry-wide R&D by ratepayer levies through EPRI and GRI has enhanced the ability of both industries to respond to R&D needs and provided an alternative to some government-sponsored R&D, but the total annual budgets of the two institutions (less than $300 million and $100 million respectively) are far too small to permit them even to contemplate financing demonstration or first-of-a-kind commercial plants at a billion or more each.

Some energy-related industries are too fragmented to organize and finance a strong R&D response to market signals. Individual units lack the financial strength, and realize too well that the benefits would accrue mainly to other units.

*Emphasis added.

> Even where some larger units exist, industries with a strong R&D orientation and capability are the exception in America. Most of our industry-sponsored R&D is now highly concentrated in a few industries. The reasons may be historical, institutional, or advantageous. A strong R&D response to price signals requires both motivation and capability. In many cases the capability is simply lacking, and while it can be developed in given time, the time required to build a strong research organization is measured in years.

In establishing federal energy R&D priorities consistent with the Administration's policy of concentrating its funds on long-term, high-risk research that will not be funded by industry in response to market incentives and in recognition of the need to reduce the level of federal expenditures, it is recommended that the following principles be followed:

- o If successful, the research will have a national benefit. Either the resource base is sufficiently large or the potential so great, that a successful program can have an impact on national energy policy.
- o The basic federal policy of funding only long-term, high-risk energy R&D will be applied consistently to all sectors. Near-term research results can only be commercialized by industry; therefore, this is a proper role for industry.
- o The benefits of the research cannot be captured by an individual firm. The results must be broad and applicable across an entire sector.
- o The research must have significant cofunding (actual cash) by industry before any technology will be developed at the large pilot plant scale. This should help ensure that the research potential is very good or industry won't contribute funds.
- o The unique disincentives for the regulated industries to fund R&D will be recognized. This will require a coordinated transition to shift funding to these industries.
- o The different responses between the regulated and nonregulated industries to free market pricing for energy and the subsequent ability to rapidly and significantly increase R&D funds must be recognized.
- o Federal funding of energy R&D will not intentionally favor one energy sector in comparison to other sectors.

Establishing federal energy R&D priorities using the above principles would provide for equitable treatment of all sectors of the energy market and will ensure that the research is in the national interest. A statement of the basic principles and new R&D priorities should be stated in clear, concise terms for public debate. The policy should not be created through the budget documents, but rather the budget documents should reflect policy.

Impact of Uncertanities of Federal Energy Policy

Industry, especially the regulated sectors of the energy industry, cannot rapidly respond to abrupt changes in federal energy R&D policy. As an example, GRI's activities are planned and funded through a mechanism that is subject to an annual review and approval by the FERC and, where intrastate sources of gas are involved, also by the cognizant state regulatory commissions. This procedure requires approximately 15 months from the time the R&D plan is developed until it is finally approved. This allows sufficient time for the extensive review process necessary to establish that the planned research is in the public interest and will be of substantial net benefit to the gas ratepayers. However, it also precludes the gas industry, through GRI, from rapidly shifting or increasing its R&D funding.

In its 1982 application to the FERC, GRI emphasized the reduction in near-term federal R&D for gas-related research and accordingly increased its research funding in those areas. In fact, funding for near-term projects in efficient utilization and safety and distribution research was increased by 45 percent as compared to an overall research budget increase of 22 percent. In approving the GRI 1982 research program, the Commission stated in Opinion No. 131:

> GRI is not a government entity; it is the agent of its members in conducting R&D on behalf of the regulated gas industry. The Department of Energy agrees that GRI represents the private sector and that GRI and the private

> sector in general must, in view of DOE's withdrawal from near-term energy R&D, fund more--not less--of these activities. We agree.

In planning its 1983 research program, GRI is proposing to significantly increase its budget for near-term research. Of the planned increase of approximately $36 million for contract research ($83.7 million to approximately $120 million), over $30 million will be for near-term research to offset the loss of DOE cofunding.

With GRI's shifting its research to offset part of the DOE reduction in near-term research, recent predictions of further federal budget cuts in gas-related research and termination of several long-term, high-risk research projects cause significant concern.

Moreover, for a long time I have expressed my deep concern to DOE and its predecessor agencies about the disproportionate federal support of electric power RD&D as contrasted to federal support of gas-related RD&D which has lingered at 10 percent or less, although gas has and is expected to play a very major role in meeting U.S. energy requiements. Thus, reports on likely increases in the already huge nuclear RD&D effort while unconventional natural gas production, geopressured methane, underground coal gasification, and advanced gas utilization technology RD&D are severely curtailed, further increase my concern about the priorities of the federal energy RD&D budget.

To be more specific, let me comment on three proposed shifts in federal RD&D policy that should be examined in detail.

- Major cuts in research on unconventional natural gas are based on the assumption that natural gas prices will be deregulated. Even if natural gas is deregulated at the wellhead, these potentially major supplemental sources of competitive-cost gas may not make a major contribution prior to 2000 because unconventional gas sources compete poorly for investment dollars with traditional exploration for conventional oil and gas. There is little that is able to be patented or licensed, and individual holdings are so small that the R&D cost per unit of production is high. Consequently, companies are reluctant to expend sufficient R&D to develop the technology required to produce any but the geologically most favorable unconventional gas resources. Industry R&D, to date and in the foreseeable future, therefore, is limited to high payoff, near-term efforts. A government/gas industry research program needs to be continued if we are to tap these resources.

- Elimination of government conservation research programs, which have been underway for several years, such as fuel cells, industrial processes, and technology development that uses gas should be examined on an individual basis to be sure that the industrial infrastructure is in place for industry to assume the research funding before these programs are abruptly cancelled.
- The further reduction of the already minimal federal support of gas-related RD&D assumes that this represents even-handed treatment between the oil and regulated gas industry. Increased prices for gas do not enhance the ability of the regulated gas industry to fund increased R&D.

The one key concern that I have which is common to all of the above policy issues is that ongoing quality research programs will be cancelled under the assumption that industry is able to automatically respond and continue the research. All industries are not alike, and therefore, a blanket assumption that what is true for the oil industry is also true for the gas industry is erroneous. It is for these reasons that any simplistic assumptions about the ability of the regulated gas industry to instantaneously increase its funding of energy R&D to offset reductions in federal funding will lead to a further reduction in the gas technology base and increased oil imports.

Examples of Federal Role in Long-Term Gas Research

There are important high-risk, long-term, high payoff areas of gas-related research that continue to require government sponsorship. This research meets the Administration's policy guidelines and is consistent with the principles and R&D priorities outlined in the preceeding section. It is especially important for the government to maintain a strong long-term, gas-related R&D program now while GRI and the gas industry are in the process of restructuring its strategy in order to take the lead in near-term R&D as the government rapidly abandons these programs. During the 1982 to 1986 time period when the gas industry is significantly increasing its funding of near-term R&D, the federal government must maintain viable funding for critical energy R&D programs and strengthen its long-term gas R&D programs. A complete list of recommended federal funding and projects for long-term, gas-related R&D in FY 1983 is presented in the first two exhibits at the end of the testimony. It should be noted that this recommendation, while totalling approximately $100 million, is only half the level of funds appropriated by Congress for gas-related research in FY 1982. This is consistent with the necessity to reduce the level of federal expenditures, but at the same time it continues critical, ongoing, long-term gas R&D programs.

Following are discussions of four examples taken from these recommendations. These discussions highlight the long-term research needs of each technology.

UNDERGROUND COAL GASIFICATION

Underground coal gasification (UCG) is an excellent example of a research area that clearly meets the Administration's requirements. The high risks associated with UCG technology currently preclude industry from developing the technology on its own. Before industry would be willing to make major investments, several basic technology issues must be resolved such as the ability to successfully link modules. DOE should carry this program forward to the "proof of concept" point. UCG offers the largest potential for major reductions in capital investments of the different processes and methods for producing a medium-Btu gas from coal. One of the benefits of UCG is that the development of this technology is not specific to any end product. The gas produced from oxygen-blown UCG differs little from the synthesis gases produced in conventional surface gasification processes and can be converted to a variety of end products--synthetic pipeline gas, synthetic hydrocarbon liquids, methanol, hydrogen or ammonia. DOE should concentrate on developing the technology to produce a synthesis gas rather than on a particular end product and leave industry with the flexibility to make the decision on what product to produce based on market conditions.

In addition to UCG's benefits as a source of gases and liquids, the successful development of UCG technology would significantly expand the utility of the extensive U.S. coal reserves and resources. This technology is intended to exploit coal seams that are too steeply dipping, too deep, too thin, or of marginal quality for economic surface or deep shaft mining. Thus, underground gasification does not compete with surface gasification for available domestic coal resources. Analysis by DOE/LLNL indicates that of the 6.4 trillion tons of domestic coal resources only 450 billion tons are currently economically mineable and therefore can be counted as proved reserves. Of the remaining sources, DOE estimates that 1.8 trillion tons may be suitable for exploitation by underground gasification. UCG, therefore, represents a technology with an enormous potential for increasing the size of our coal reserves. This has implications that go beyond the obvious benefit of increasing long-range supplies of indigenous energy resources. The federal government owns or controls four-fifths of the coal west of the Mississippi. The government needs to know whether or not UCG works and is economical to assess the value of its extensive holdings. The successful development of the technology could significantly increase the value of the land the government intends to lease and ensure cost-competitive long-term gas supplies.

BIOMASS

Key targets for major long-term R&D investments are land- and marine-based biomass production and conversion. Not only is biomass a credible option for long-term energy supply throughout the world, it is also a critical hedge technology in case the coal options cannot be fully exploited because of the carbon dioxide problem and in case the nuclear option continues to falter because of socio-political, operational, or economic reasons. The problem here, of course, is proper planning so that energy crops do not compete with food crops for scarce arable land. That is why the ocean alternative looks so promising. But our own recent experience with the agricultural industry of Florida also points to the possibility of rotation of food and energy crops and other schemes that do not compromise food production. In either case, land or marine biomass, the potential of biomass R&D is staggering when one considers the work still to be done in hybrids and genetic engineering, let alone in the agricultural sciences and on the economic development of anaerobic digestion technology.

GEOPRESSURED METHANE

We need to know more about the magnitude of the resource and potential for economic production of methane dissolved in the brines of the geopressured aquifers located on- and off-shore along the Gulf Coast. The science of locating geopressured gas resources and of assessing their size, geophysical and chemical properties, and recovery potential is in its infancy. Little is known about the geologic and productivity characteristics of potential reservoirs as they relate to the required economic rate of fluid delivery ability. Little data is available in the public domain on the physical and chemical characteristics of the contained waters, such as temperature, pressure, and any dissolved contaminate. A long-range research program is needed to gather the scientific information necessary to understand this potentially important national resource. The private sector is unlikely to make investments in this resource because drilling and production costs are uncertain and the majority of the resource is located on federal land. A substantial multi-year research program must be carried out as part of the overall federal long-term R&D role to reduce the uncertainties associated with methane in geopressured aquifiers. Only through this proper federal program can the true potential of this national resource be assessed.

UNCONVENTIONAL GAS

Unconventional gas sources compete poorly for investment dollars with traditional exploration for conventional oil and gas. The substantial improvements in the performance of the technology required to improve the attractiveness of the unconventional resources relative to lower-risk gas sources, including foreign sources, require complex, expensive, and high-risk R&D. There is little that is patentable or licensable and individual holdings are so small that the R&D cost per unit of production is high. Consequently, companies are reluctant to expend sufficient R&D funds to develop the technology required to produce any but the geologically most favorable unconventional gas resources. Industry R&D, to date and in the foreseeable future, therefore, is limited to high-payoff, near-term efforts.

GRI is sponsoring a research program aimed at increasing production in near-term resources. However, federal sponsorship is needed to increase our understanding of the properties affecting reservoir stimulation and gas production in tight formations. This is particularly important in the lenticular formations in the West and the Devonian shales in the East. The responsibility for production-oriented research, and trial and error drilling should be left with industry. DOE should concentrate on performing experiments that are unlikely to ever be conducted by industry, but which could greatly enhance our understanding of these formations through the conduct of novel experiments. Two particularly good examples of novel experiments that would not be conducted by an individual firm are the Eastern Mineback Program in the Devonian shales and Multi-Well Experiment in the West. The Eastern Mineback Program is designed to substantiate the methodology and results of stimulation technology through a series of experiments. Unlike previous experiments, researchers will have the capability of making actual physical measurements and detailed instrumental observations of the shale in place to determine the effect of stimulation, the behavior and extent of fracture, and the accuracy of diagnostic tools among other factors. Through this program, researchers will be able to assess the accuracy of present models and provide an accurate assessment of the in-situ reservoir.

The multi-well experiment is designed to obtain the maximum amount of technical understanding of lenticular formations. The normal economic constraints of a private firm would prohibit the conduct of an experiment of this type where wells are drilled far closer to each other than would ever be done commercially to allow flow and pressure testing between wells, well-to-well geophysical testing, and examination of geological continuity. The results are data and information that can be applied by a broad spectrum of industry.

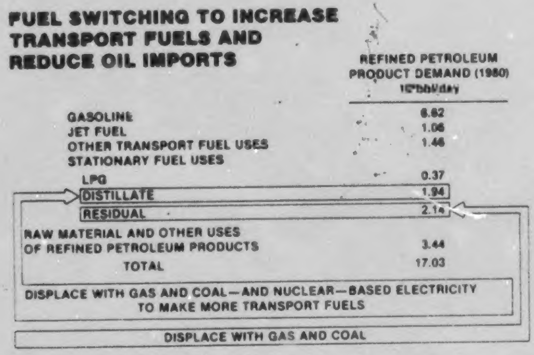
Summary and Recommendations

The potential to have a significant increase in oil imports in the industrial and power plant market is large and is a national energy policy issue. An excessive flyup of natural gas wellhead prices upon decontrol in combination with a lack of an adequate gas technology base could lead to permanent displacement of gas with imported oil in relatively low-technology heat energy applications. It is estimated that something on the order of three to four million barrels per day could be switched, a third of it very quickly.

GAS IN STATIONARY APPLICATIONS

The most critical problem from the national interest viewpoint is the need for gas to remain competitive (and be allowed to compete) in the industrial and power plant markets. Unless domestic gas, and secure North American gas in general, keeps its competitive position in the industrial and power plant markets vis-a-vis imported oil, the gratifying decline of more than three million barrels per day in oil imports from their peak in 1977, and the closely related softening of world oil prices, will be reversed.

As an example of the role gas can play as part of a national effort to reduce oil imports, gas has already replaced 450,000 barrels per day of oil in stationary applications in the last two years. The potential for additional reductions in imported oil through gas substitution is very large (as shown below) and must be examined and given fair consideration as one of the key elements of a long-range solution to the oil import dependence and vulnerability problem.



FUEL SWITCHING TO INCREASE TRANSPORT FUELS AND REDUCE OIL IMPORTS

	REFINED PETROLEUM PRODUCT DEMAND (1980) 10^6bbl/day
GASOLINE	6.62
JET FUEL	1.06
OTHER TRANSPORT FUEL USES	1.46
STATIONARY FUEL USES	
LPG	0.37
DISTILLATE	1.94
RESIDUAL	2.14
RAW MATERIAL AND OTHER USES OF REFINED PETROLEUM PRODUCTS	3.44
TOTAL	17.03

DISPLACE WITH GAS AND COAL—AND NUCLEAR—BASED ELECTRICITY TO MAKE MORE TRANSPORT FUELS

DISPLACE WITH GAS AND COAL

Data Source: EIA 1980 Annual Report to Congress

THE NEED FOR AN IMPROVED TECHNOLOGY BASE

The challenge facing the nation and the gas industry will be how to retain or expand its industrial markets and retain a portion of its utility markets, thereby constraining oil imports, while continuing to provide reliable residential/commercial service at the least possible cost to consumers. To respond effectively to this challenge will require major improvements in the gas technology base on both the supply and utilization ends.

The rapid cutback of DOE Fossil Energy and especially gas-related RD&D will require a substantial change in the funding and R&D strategy of GRI if an adequate technology base is to be developed and maintained. Much of the effectiveness of GRI's program has depended on supplementing GRI's limited funds by cofunding or cooperative funding of projects of common interest with DOE and other government agencies. Not only has this stimulated more cooperatively funded gas-related R&D, but is has also allowed the gas consumer to gain exceptionally high benefits from its R&D investments.

With the recent change in government cofunding prospects, this strategy must be reassessed. One remedy with many side benefits is to seek increased cofunding with industry. Not only does this provide a potential substitute for government support, it also improves the prospects for commercialization. Such a shift will require time. Thus, it is extremely critical that ongoing federally supported R&D programs related to gas supply and use not be abruptly cancelled under the assumption that the regulated gas industry will be able to instantaneously increase its collection of R&D funds and continue the work at an adequate rate.

RECOMMENDATIONS FOR STABILIZING ENERGY R&D PLANNING AND BUDGET

The following steps would help to stabilize energy R&D planning and to provide consistent guidance to industry during the next few years as the transition from a vast federal role in energy policy and funding to a limited federal presence in long-term, high-risk research is completed. Without these steps, the transition may be abrupt and critical research in the national interest eliminated.

1. Expand and continue Congressional hearings, such as the one today, to get a full debate on the proper federal role and procedures necessary to establish federal energy R&D priorities in the national interest.
2. Develop in the federal budget total program costs for major energy projects. This will allow Congress to debate the merits of projects with the full knowledge of future budget requirements.
3. Consider total program authorization for major energy programs, not just hardware development programs. This would allow program managers to develop program plans and schedules based on research needs and technical progress rather than uncertain annual budgets.
4. Conduct oversight hearings on a biannual basis to verify that major energy programs still offer promise and are making sufficient technical progress.
5. Provide for multi-year appropriations to allow for proper program planning.

Much of the new emphasis on letting the market determine the introduction of new energy sources and technologies is basically sound. However, there is a continuing need for federal support of RD&D which is clearly in the national and consumer interest and which will not be performed by the private sector in response to market forces for a variety of institutional reasons. In its examination of the FY 1983 budget, I ask the Committee to consider:

- Competing energy sources should be accorded equitable RD&D funding.
- If measures intended to achieve market ordering have such undesirable side effects as increased oil imports, uneconomical levels of electrification, and shrinking gas markets, they should be avoided.
- The current technology base and ability of the regulated segments of the energy industry to significantly increase funding of energy RD&D is severely limited compared to the

unregulated segments of the industry. Therefore, they require a transition period in order to absorb the near-term R&D previously performed by DOE.

- Federal funding of long-term, high-risk, gas-related research is in the national interest.
- Long-term efficient utilization technologies need continued federal R&D support because the needs of the consumer are not fully served by equipment and appliance manufacturers. Fuel cells, advanced gas prime movers, and industrial cogeneration processes are examples meriting such support.

While most of my testimony concerns the impact of policy and funding uncertainty on the research efforts of the regulated gas industry, I do want to mention one group that is especially hard hit by the rapid changes and continuing uncertainty. Our nation's universities, especially at the graduate school level, are seriously impacted by funding uncertainty. In selecting a research topic for a thesis, the master's or doctoral candidate must be reasonably certain that the period of funding will last long enough for him to complete his dissertation. It must certainly be a bitter experience to complete half of a dissertation under the active support and encouragement of your university and federal government and then suddenly to have your funding terminated. Constantly changing policies discourage many of our best graduate students from applying their knowledge and energy to crucial areas of energy research. I hope this Committee will encourage DOE to be especially sensitive both to the vulnerability of our universities and especially to our students in considering which projects to delay or cancel.

That concludes my formal testimony. Again, I thank the Committee very much for the opportunity to testify. I will be glad to answer any questions you may have.

Recommended FY 1983 DOE Funding Required for Minimum Gas-Related Long-Term Research Programs
($ Millions)

Fossil Energy

Tight Sands (lenticular)	$ 6
Devonian Shale (eastern mineback)	6
Advanced Unconventional Natural Gas (gas hydrates, abiogenic methane)	4
In-Situ Coal Gasification	10
Geopressured Methane (two new hydropressure wells, flow tests)	16
Coal Gasification (advanced gasification, catalysts/basic research, materials, Great Plains)	35
Advanced Fuel Cell Technology Development (molten carbonate, advanced concepts, on-site phosphoric acid)	15
Subtotal	$92

DOE Funding Recommendations (cont'd)

Solar

Biomass Conversion (digester research)	$ 3
Genetic Engineering and Biomass Growth	2

Conservation

Advanced Gas Prime Mover	4
Hydrogen	3
Subtotal	$ 7
TOTAL	$104

PRINCIPLES FOR ESTABLISHING R&D PRIORITIES

1. Results Must be of National Benefit

2. Apply Federal Policies Consistently

3. Only Industry Can Effectively Introduce New Products into the Marketplace

4. Recognize Past Federal Funding for Energy R&D Has Created Distortions

5. Recognize that Economic Rents for Higher Energy Prices are not Captured by Regulated Industries

RECOMMENDED FEDERAL R&D PRIORITIES

1. Concentrate on Long-Term, High-Risk Research

2. Continue Long-Term Fossil Energy Research

3. Continue Long-Term Generic Research in Efficient Utilization of Energy

4. Concentrate on Research that Develops Generic Data which can be Applied by a Broad Sector of Industry

5. Allocate Research Dollars in Relation to the Potential Contribution of the Resource Technology

6. Provide an Adequate Transition Period for Industry to Assume Funding of Near-Term Research Recognizing Different Response Times for Regulated vs. Non-Regulated Industries

7. Fund No Research Beyond Proof-of-Concept without Industry Cofunding

Mr. **Fuqua**. Thank you very much, David, for a very fine statement.

Our next witness will be Mr. Vico Henriques, the president of the Computer and Business Equipment Manufacturers Association.

We are happy to welcome you here this morning. Likewise, if you wish to make your statement part of the record and summarize, we will be happy to do that.

STATEMENT OF VICO E. HENRIQUES, PRESIDENT, COMPUTER AND BUSINESS EQUIPMENT MANUFACTURERS ASSOCIATION

Mr. **Henriques**. Thank you. I would like to do that, Mr. Chairman—submit my statement for the record.

Mr. **Fuqua**. Without objection, permission to take photographs and recordings will be granted.

Mr. **Henriques**. Mr. Chairman, it is a pleasure to be here this morning.

I represent the Computer and Business Equipment Manufacturers Association. We have some 40 members in the high technology area of computers and business equipment. Our membership includes both small and large companies, and in 1981 the industry had worldwide gross revenues of over $50 billion and positive trade balance of $6 billion.

We would like to take the opportunity today to point out that we do have concerns about some effects of the budgetary cutbacks, but at the same time our industry commends the administration for its efforts to reduce inflation and to place the Nation on a more stable fiscal footing.

Our industry does not now rely heavily on government-sponsored R. & D., as we did in the early days of the industry. We are the indirect recipients of much of the benefits that come from government R. & D. The main recipient of government funding for R. & D., as we are aware, are the universities and colleges of America, federally-funded laboratories, and others of similar nature from whom you will hear. Much of the basic research goes on in the university atmosphere.

Industrial applied research and development, on the other hand, is equally as important. Federal, State, and local government funds account for 75 percent of the funding, while industrial funds and nonprofit institutions apply an additional 21 percent.

I am pleased that Dr. Saxon gets 5 percent from industrial sources. Our national average figures, I think, are a little bit below that. I think they range somewhere in the 4 percent level for support of basic research.

I would like to state also that federally funded R. & D. has brought numerous developments, which would be severely hampered by any long-term reduction in that funding. The commitment to technological preeminence in the United States requires that the storehouse of knowledge continually be replenished and expanded. If we act to enable the Nation's high technology industries to participate in the development of the science as well as the resultant products, we will go a long way toward assuring our continued technological preeminence.

As a result of the intensive effort in R. & D. over the last 50 years, there has been the development of a group of high-technology industries which have, in turn, produced products responsible for much of the Nation's economic progress. These industries are the primary industrial performers of R. & D. as well as major consumers of science and technology.

Our analysis has shown that there must be an appropriate balance between research and development. To this end, we believe that the Government should structure its tax and fiscal policies to encourage scientific research and industrial innovation. The tax credits for research and development are of significant advantage in promoting new investment and in encouraging innovation.

While bolstering industry/university cooperation is important, it is equally important to recognize the necessity of industrial applied research and development. The truncation of a process from basic research, through development, to final product must be avoided. Equal emphasis should be given to academic and to industrial R. & D.

In order to infuse new capital, it is necessary to take into account the serious effect that inflation has had on capital recovery. Much of the industry which I represent has capital investment the useful life of which is less than 5 years, and the effect of inflation on capital recovery and reinvestment for research purposes can be easily seen.

Likewise, the United States should not dogmatically nor shortsightedly impose tax burdens upon its ability to compete. In the world there are diverse tax philosophies and systems in which other nations manipulate tax policy to promote their national objectives. The concept of tax neutrality may have certain merits which should be considered. Tax discrimination against foreign source income clearly puts U.S. firms operating abroad at a disadvantage and should be avoided.

As I mentioned, our R. & D. is capital intensive. Many subjects lend themselves to the joint research projects of the university-industry or intraindustry variety, but this kind of research is lean in the United States, because the solutions to the proprietary and antitrust problems that beset this kind of research are widespread and the solutions need to be made before the full effects of research revitalization can be realized.

I would like to turn to one of our major concerns now, which is the existing and growing shortage of technical and scientific personnel. We link this closely to the availability of university programs funded in large part by the Federal Government.

One of the critical parts of the science and technology infrastructure is the Nation's education system. We are experiencing shortages of qualified personnel in several specific areas, notably computer science and some fields of engineering. We are told that these shortages may extend to other technical fields in coming years.

Unfortunately, the high demand for the best young talent in industry is having a deleterious effect on the Nation's universities. Not only are they finding it difficult to recruit and retain faculty, but they also find it increasingly difficult to attract graduate students.

The domestic computer industry will have a yearly growth of 4 to 5 percent in the 1980's. Computer-related jobs are expected to reach 2.1 million by 1990. In the information processing field alone, there will be major needs for engineers, computer scientists, technicians, operators, and word processing personnel.

In the recently completed National Science Foundation-funded study by Dr. Gillespie, who is the provost for computing at the University of Washington, in the BA/BS level a supply of 13,000 graduates in computer science was provided for 54,000 openings; at the master's level there were 3,400 graduates against 34,000 openings; and at the doctoral level, 330 graduates for 1,300 openings.

To maintain our technological lead, we must realize, as Japan and the Soviet Union have, and whose universities are graduating record numbers of engineers, that there is an increasing need for technical and science graduates. While the United States in 1980 graduated 58,000 bachelor's degree engineers, Japan graduated 74,000 and the Soviet Union 300,000.

We are convinced that, given the current situation, we are risking that the United States in the foreseeable future could risk losing its lead in the technological world, and we urge you and your committee to continue in your efforts to keep the Congress and other branches of Government aware and ready to act to assure that the United States maintains its lead in this area.

We initiated within our association a program to help lessen the severity of the problem. I have appended to my formal statement a publication relating to educational guidelines for service technicians. We are, as well, working at the undergraduate and graduate level to provide guidance, assistance, and direction to promote greater emphasis on technical and science education at the universities and colleges in the country.

Although I have stated that the Government must continue to fund adequately R. & D., this is not to say that the Government has sat idly by while the situation has worsened.

We commend the Congress for its hard work and foresight in the passage of the Economic Recovery Tax Act of 1981. It is my opinion that the Government has realized that it has a shared interest with industry in the production of highly skilled scientists and engineers.

Title 2 of that law provides in part for a tax credit of 25 percent of the qualified research expenditures of a corporation for the taxable year over the base period research expenses. The law allows the 25 percent credit for 65 percent of all payments to universities to perform basic research. Companies are also permitted a larger deduction for charitable contributions of equipment used in scientific research. Although we welcome these recent changes, the opportunity to do more to keep the United States in the technological lead still remains, and we urge you and are encouraged, Mr. Chairman, by the efforts of this committee.

One last item I would like to address at this time is the defense establishment's ability to lure away from academia the most skilled scientists and engineers. We all fully realize the need for this type of talent in order to insure our national security. However, given the shortage with which we are now faced and the likelihood of its imminent growth, we must establish a balance so that all interests, defense and civilian, are adequately served.

Thank you, Mr. Chairman, for the opportunity to be here today. I will be glad to answer any questions you may have.

[The prepared statement of Mr. Henriques follows:]

STATEMENT OF
VICO E. HENRIQUES, PRESIDENT
COMPUTER AND BUSINESS EQUIPMENT MANUFACTURERS ASSOCIATION
BEFORE THE HOUSE COMMITTEE ON
SCIENCE AND TECHNOLOGY
FEBRUARY 2, 1982

Mr. Chairman and members of the Committee, I am Vico E. Henriques, President of the Computer and Business Equipment Manufacturers Association (CBEMA). It is my pleasure to appear before you today to discuss the possible ramifications to Federally sponsored research and development as a result of Governmental budget reductions. CBEMA is a trade association representing the major manufacturers of computers and business equipment in the United States. Our membership includes both large and small manufacturers of such equipment and represents an industry which in 1981 had gross revenues of over $50 billion and a positive balance of trade of $7 billion.

I would like to take this opportunity to point out that although we do have concerns about some of the effects of the budgetary cutbacks, we commend the Administration for its efforts to reduce inflation and to place the nation on a more stable fiscal footing.

Although the industry which I represent does not rely heavily on Government sponsored R&D, we are indirect recipients of the many benefits which have come from Government R&D. The main recipient of Government funding for R&D as we are all aware are America's colleges, universities and Federally funded laboratories which you will hear from during these proceedings. Academic R&D focuses on basic work. Nearly 70 percent of all university research is basic research. Federal, state and local government funds account for 75 percent of the funding while institutional funds and non-profit institutions supply an additional 21 percent. Private industry is responsible for only 4 percent of the support for basic research. However, I am quite sure that the representatives of those institutions are better informed than I to speak to their concerns.

I would like to state however, that Federally funded R&D has brought forth numerous developments to this nation and I sincerely hope that the Administration takes into account the long-range effects of any reductions to that funding.

The commitment to U.S. technological preeminence requires that the storehouse of knowledge continually be replenished and expanded. If we act to enable this nation's high technology industries to both participate in the development of the science, as well as the resultant products and processes, we will go a long way toward assuring our future.

The benefits of research and development to the U.S. economy and American society have been substantial. A result of the intensive effort in R&D over the last fifty years has been the development of a group of high technology industries which have, in turn, produced the products responsible for much of this nation's economic progress. These industries are the primary industrial performers of R&D as well as major consumers of science and technology. The economic facts of life more that justify actions to promote increases in the level of R&D performance by these industries.

Our analysis shows that there must be an appropriate balance between research and development. CBEMA believes the U.S. Government should structure its tax and fiscal policies to encourage scientific research and industrial innovation. Tax credits for research and development are of significant advantage in promoting new investment and in encouraging innovation. We suggest that, while bolstering industry-university cooperation is important, it is equally important to recognize the necessity of industrial applied research and development. The truncation of the process from basic research through development, to final product must be avoided. Equal emphasis should be given to academic and industrial R&D. In order to infuse new capital, it is necessary to take into account the serious effect that inflation has on capital recovery. Much of the industry I represent has capital investment, the useful life of which is less than five years.

The U.S. should not dogmatically or short-sightedly impose tax burdens upon its ability to compete. In a world of diverse tax philosophies and systems in which other nations manipulate tax policy to promote their national objectives, the concept of tax "neutrality" may have certain merits which should be considered. Tax discrimination against foreign-source income clearly puts American firms operating abroad at a disadvantage and should be avoided.

The nature of high-technology research is capital-intensive. Many subjects lend themselves to joint research projects of the university-industry and intra-industry variety. Solution of the proprietary and anti-trust problems for these kinds of research will be necessary before the full effects of research revitalization can be realized.

One concern which I would like to address at this time is that of the existing and growing shortage of technical and scientific personnel which is closely tied to the availability of university programs funded in large part by the Federal Government.

Certainly one of the critical parts of the science and technology infrastructure is the nation's education system. We are today experiencing shortages of qualified personnel in several specific areas--notably computer science and some fields of engineering--and are told that these shortages may extend to additional technical fields in coming years. These shortages result primarily from the good health and vitality of some very productive industries, which are growing rapidly. Unfortunately, the accompanying high demand for the best young talent is having a deleterious effect on our nation's universities. Not only are the universities finding it increasingly difficlut to recruit and retain faculty, but they also find it increasingly difficult to attract graduate students. The domestic computer industry will have a yearly growth rate of 4 to 5.1 percent in the 1980's according to the Bureau of Labor Statistics. Computer related jobs are expected to reach 2.14 million by 1990. In the information processing field alone, there will be major needs for engineers, computer scientists, technicians, computer operators, and word processing personnel. As an illustration of the shortages which we currently face in computer science alone in BA/BS level, a supply of 13,000 graduates for 54,000 openings; MS level, 3,400 graduates for 34,000 openings; and, the Doctorate level, 330 graduates for 1,300 openings.

In order to maintain our technological lead, we must realize, as Japan and the Soviet Union have realized, and whose universities are graduating record numbers of engineers, that there is an increasing need for technical and science graduates. While the United Stated graduated 58,000 bachelor's degree engineers in 1980, Japan graduated 74,000 and the Soviet Union 300,000.

We have studied this problem in quite some detail and we are convinced that given the current situation here and abroad, we are risking that the United States will in the forseeable future risk losing its lead in the technological world. We urge you and your Committee to continue in your efforts to keep the Congress and other branches of government aware and ready to act to assure that the U.S. maintains its lead in this area.

We have initiated efforts within our Association and its member companies to help lessen the severity of the problem. I have appended to my Statement CBEMA's publication Educational Guidelines for Service Technicians. The purpose of our brochure is to help stimulate the supply of service technicians and other technically educated and trained professionals. We are providing these guidelines to educational and training institutions to help them update their courses with the latest technological and personal requirements. In addition to our Association's activities, we have been actively promoting and working with other associations in the high-technology field to promote greater emphasis on technical and science education on both graduate and undergraduate levels.

Although I have stated that the Government must continue to adequately fund R&D, that is not to say that the Government has sat idly by while the situation has worsened. We commend the Congress for its hard work and foresight in the passage of PL 97-34, the Economic Recovery Tax Act of 1981. It is my opinion that the Government has realized that it has a shared interest with industry in the production of highly skilled scientists and engineers. Title II of that law provides, in part, for a tax credit of 25 percent of the qualified research expenditures of a corporation for the taxable year over the base period research expenses. Qualified expenses include in-house expenses and contract expenses. The base period is the three taxable years immediately preceeding the taxable year for which the determination is being made, with the exception of the transition years. The law also allows the 25 percent tax credit for 65 percent of all payments to universities to perform basic research. Companies are also permitted a larger deduction for charitable contributions of equipment used in scientific research.

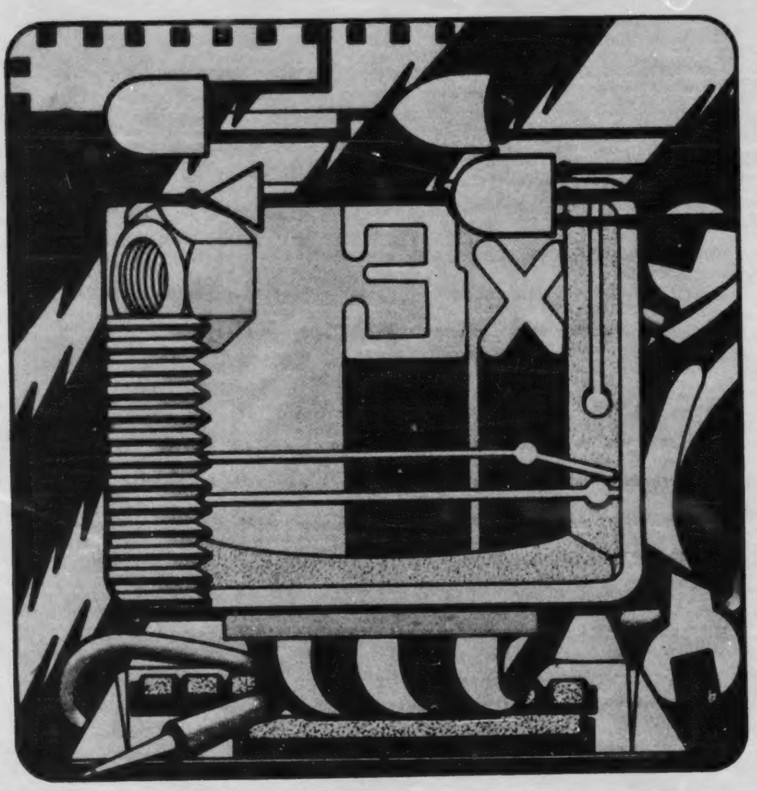
Although industry welcomes these recent changes, the opportunity to do more to keep the United States in the technological lead still remains. Again, we urge you and your Committee Mr. Chairman to continue your efforts.

The matters which I have addressed today are of concern to my industry and to the nation. One last item which I would like to address at this time is that of the Defense establishment's ability to lure away from academia the most skilled scientists and engineers. We all fully realize the need for this type of talent in order to ensure our national security. However, given the shortage with which we are now faced and the likelihood of its imminent growth, we must establish a balance so that all interests are adequately served.

Thank you for the opportunity to appear today and I would be pleased to answer any questions you may have.

CBEMA

Educational Guidelines for Service Technicians



The Computer and Business Equipment Manufacturers Association, a national trade association, represents the common interests of a highly competitive and diverse segment of the U.S. economy—producers of computers and business equipment.

Beginning early in this century with the introduction of typewriters, cash registers and adding machines, this industry has contributed greatly to the flow of goods and services and to the health of society.

Ideas and technology from these companies have made the office, the factory, and recently the home, more efficient and more productive. Industry achievements affect the daily lives of all. They help to diagnose and treat disease, to explore outer space, and to strengthen an educational system that is one of the best in the world.

The rapidly growing information sector, CBEMA members at its core, now accounts for more than half of the nation's gross national product. CBEMA members employ nearly one million people, a quarter million of these abroad, to provide the products for processing information.

CBEMA members account for 85 percent of the sales volume of computers and business equipment produced in the United States. Internationally, CBEMA members' products and services make a large positive contribution to the United States trade balance.

Organized in 1916, CBEMA has kept pace with rapid changes in the industry: from simple office files to typing devices to highly advanced computers and office systems.

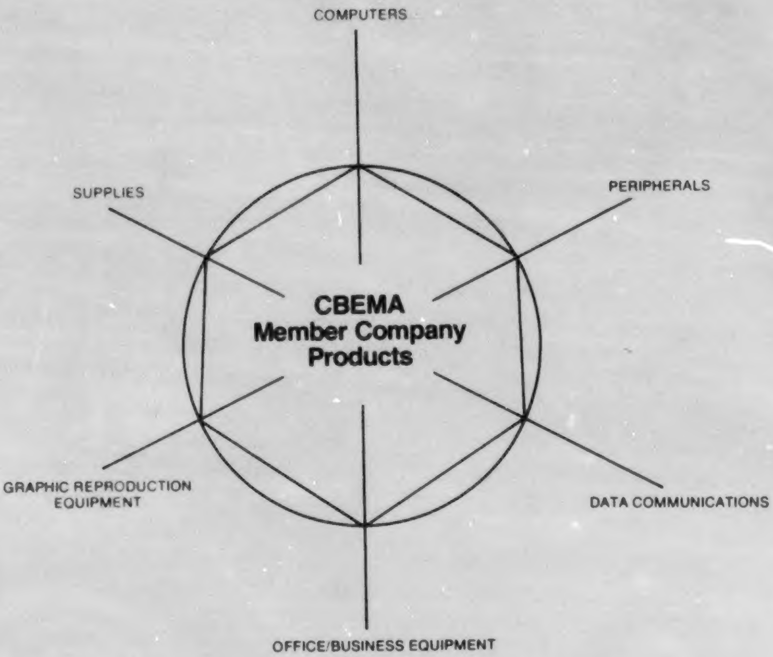
Creators of the "computer age" and the "office of the future," CBEMA members engineer, manufacture, finance, sell and provide support services for all types of business equipment, computer systems and supporting equipment and supplies. Their products range from postage meters through office copiers to word processing systems, and large scale computer systems as well as the operation of microform, data processing and other types of service centers.

The U.S. Department of Labor and other groups predict a growing need for business machine and computer service technicians (also called field engineers, customer engineers or service representatives). The industry needs an increasing number of technicians to be trained on and to provide service for the new equipment of the '80s.

To help stimulate the supply of service technicians, CBEMA has developed this brochure, "Educational Guidelines for Service Technicians." CBEMA member companies are providing these guidelines to educational and training institutions to help them update their courses with the latest technological and personal requirements for service technicians.

These guidelines confirm the dedication of the computer and business equipment industry to continued growth and to meeting the needs of community, business and government with well-qualified service personnel.

Vico E. Henriques, President
Computer and Business Equipment
Manufacturers Association


COMPUTERS
SUPPLIES
PERIPHERALS
CBEMA Member Company Products
GRAPHIC REPRODUCTION EQUIPMENT
DATA COMMUNICATIONS
OFFICE/BUSINESS EQUIPMENT

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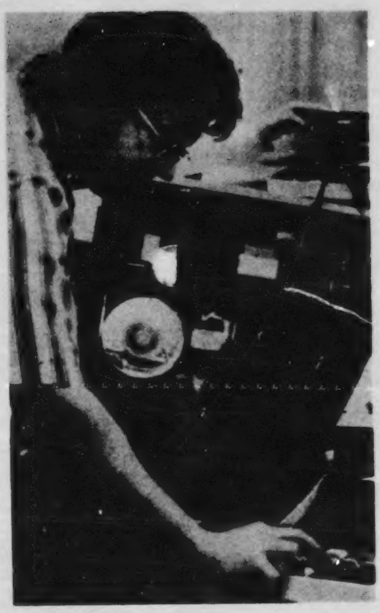


The Service Technician

Overview

The jobs of the Business Machine Service Technician and the Computer Service Technician are quite similar. These technicians may even work on both types of equipment. Rapid changes in technology are further narrowing the differences between computers and business equipment. In this brochure, both workers will be called *service technicians*.

Service technicians are responsible primarily for installing, maintaining and repairing various business machines and computer systems at customer locations.

These systems perform many functions that speed the flow of paperwork, data, information and communications now required by business, industry and government. The equipment requires periodic and emergency service: adjustment, preventive maintenance, and repair. Service technicians perform these tasks to ensure optimum equipment performance, minimal downtime, and customer satisfaction.

CBEMA member companies employ over 85 percent of all service technicians in the U.S. Operating out of local and regional offices, service technicians travel to customer locations to maintain and repair these systems.

Requirements

Technicians need strong technical knowledge and skills in electro-mechanics, electronics, diagnostics, logic and troubleshooting. They also must be expert in the use of required tools, meters and electronic test equipment.

Since most servicing is done at the customer's location, technicians must perform their work without interrupting the office routine. A neat appearance is expected. The ability to communicate effectively is essential.

Technicians must be able to work without direct supervision as well as to set up their own schedules to meet service call deadlines. All must keep up with revised maintenance procedures and manuals.

Technicians also must be able to keep records of maintenance and repairs, to keep parts inventories, to order parts, and to complete time, expense and technical reports. Some may be required to sell maintenance agreements.

Technicians must also work effectively with people—listen to customer complaints, answer questions and sometimes provide customer training in specific areas. Some technicians who service computer systems may be required to do some programming.

Because manufacturers continually develop new equipment, even experienced technicians frequently attend training courses to keep up with changing technology and to broaden their technical skills.

Applicants and Trainees

Applicants for entry level jobs may have to pass tests measuring mechanical aptitude, knowledge of electricity and electronics, manual dexterity and general intelligence. Most employers require applicants to pass a physical examination, and some require technicians to be bonded. All technicians must be able to travel periodically.

Usually new technicians are hired as trainees and attend company training courses. Here they learn the theory and specific maintenance procedures required for the equipment they will service, along with appropriate company policies, procedures and logistics specific to their work.

Trainees also receive practical experience coupled with on-the-job training which qualifies them to progress from trainee to various levels of service technician to more specialized assignments.

Opportunity

Service technicians work year-round in an industry noted for steady employment, innovative design and technological achievement. The industry offers advancement opportunities in service, sales, training, supervision and management. CBEMA member companies encourage service technicians to broaden their technical knowledge, and many pay employees' tuition for work-related courses at colleges and technical schools.

Industry Products

Computers

Large, medium, and small scale
Mini and micro

Peripherals

Magnetic tape, cassette, and disk drives
Card readers, punches
Displays
Plotters
Printers
Terminals

Data Communications

Communications controllers
Communicating terminals
Facsimile machines

Data Entry/Recording

Addressers
Data recorders
Data terminals
Embossers
Key punches/verifiers
Optical and magnetic scanners, readers, and sorters

Office/Business Equipment

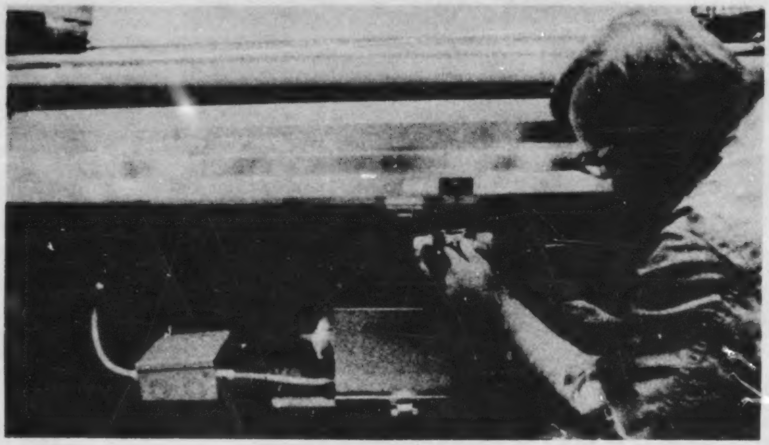
Accounting machines
Adding machines
Automatic writing systems
Bank proof machines
Binding, laminating, and shredding machines
Business forms handling equipment
Calculators
Cash registers
Dictation/transcription equipment
Labeling equipment
Mail handling equipment
Metal cabinets and furniture
Postage meters
Text editing equipment
Typewriters
Word processing equipment

Graphic Reproduction Equipment

Cold type composing equipment
Copiers and duplicators
Drafting equipment
Microfiche and microfilm cameras, processors, readers, and printers
Offset printing presses
Overhead and slide projectors
Phototypesetters
Platemakers

Supplies

Aperture cards
Business forms
Carbon paper
Chemical compounds—cleaning fluids, correction fluids, and toners
Copy paper
Film
Magnetic media—tapes, cassettes, and disks
Paper rolls
Punch cards
Ribbons



Programming, Software, and Firmware

Programming

Data processing, simply, is performing a series of operations on data to achieve the desired results. To control data processing within a computer system, a series of instructions called a program is provided to the computer to direct the way in which it performs particular operations on the data.

Computers can be programmed to simulate certain thinking processes, but they cannot think in the same way people can. Although computers, unlike people, cannot employ intuition or creativity to accomplish a task, they work with incredible speed and accuracy, storing vast amounts of information in a compact space.

By taking advantage of the computer's strengths, people have been able to control and direct the computer in thousands of applications for the great benefit of society. Through *programming*, people effect the transformation of an otherwise useless mass of hardware into an essential tool of the contemporary world.

Software

Software is defined as the part of the equipment that is not hardware. Software encompasses a variety of different programs.

For example, when numbers are entered into a pocket calculator, the software interprets where to store them and where to display the answer. This is very simple software. On the other hand, software for a large computer system is much more complex; all its different programs and controlling commands make up its *software*.

Two basic classifications of programs are used by computer systems. They are system software and application software.

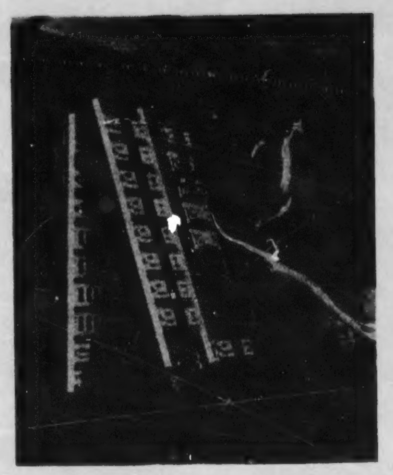
The programs making up the system software come with the computer to assist the operator. Because system software programs are designed for specific types of computers, these programs may vary greatly from one to another.

The second classification of computer programs is application software. Application software contains user programs needed to accomplish, for example, the accounting and reporting functions of a specific business, such as accounts receivable, payroll, sales analysis reports, etc. Application software varies according to a customer's needs. A city government, for instance, uses a different application of accounting software than a wholesale business or a manufacturing company uses.

Another common term is *firmware*. This may be defined as a set of micro-instructions whose function is to decode and perform the operations indicated by other instructions. In some situations, the design of software programs into hardware such as disks, tapes or chips is referred to as firmware.

Implications

Rapid changes in technology have a major impact on service technicians. History has categorized service technicians as mechanical, electro-mechanical or electronics technicians. But micronization of hardware and "computers on a chip" now allow programs and instructions to be designed into the hardware. Hardware and software increasingly interact in the new systems.



Thus, to service the products of today and tomorrow, service technicians may also have to understand programming, microcode, logic, diagnostics and control systems.

Industry Growth and Employment Opportunities

Industry Growth

The computer and business equipment industry is one of the fastest growing industries in the world.

Beginning early in this century with the introduction of typewriters, cash registers and adding machines and continuing through the development of today's sophisticated computers, copiers and word processing systems, this industry has enjoyed extraordinary growth.

But some forecasters see today as only the beginning. By the year 2000, projections indicate that the information industry will be the largest in the world.

The computer field continues to change. Of great significance is the development and growth of the mini-computer. Use of mini-computers in distributed processing and expanding small business applications causes some to estimate a 50 percent growth in their use during the 1980s.

Many office equipment products are being developed to support established product lines. Such new lines include terminals, peripherals, displays, printers, communications devices and copiers. All contribute to the continuing growth of this exciting industry.

Increasing demands of business, industry and government for more information—faster—will spur even more growth in the industry.

Employment Opportunities

The fast growing computer and business equipment industry has created many thousands of new jobs that did not exist 10 years ago.

Because of new products and new technologies, opportunities for employment in this industry increase year after year.

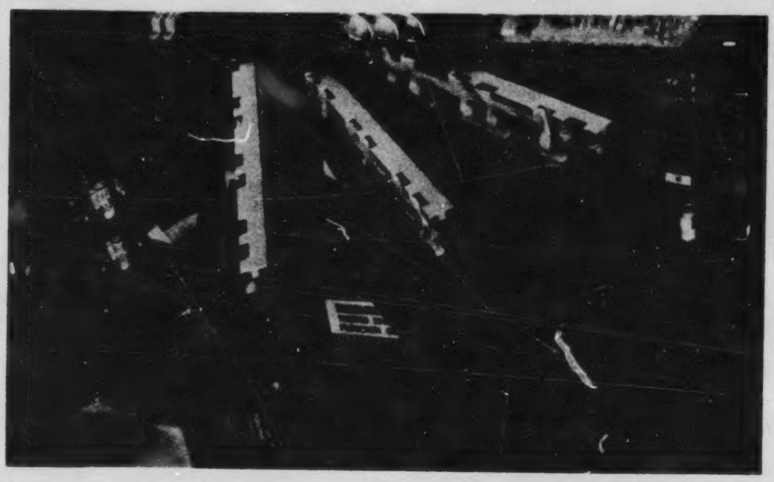
New engineering, manufacturing and maintenance methods have changed existing jobs, thus creating the need for continuing training to keep the skills of the work force up to date.

Between 1960 and 1975 when many industries were reducing work forces, the number of jobs in the computer and business equipment industry doubled. Changes in technology—from mechanical to electro-mechanical to electrical to electronic—contributed greatly to the creation of many new jobs.

But the needs of the future are even greater. The Department of Labor, Bureau of Statistics, estimates that the number of "Business Machines Repairers" jobs will increase 56 percent from 1978-1990 and the number of "Computer Service Technicians" jobs will increase 92.5 percent during that same period.

The increasing sophistication of equipment to serve both existing markets and new applications ensures a growing need for more highly qualified people to fill many new jobs.

Such continued growth in the job market will provide excellent opportunities for job security and advancement in a field that continues to become more challenging year after year.



Curriculum Guidelines

The following curriculum guidelines specify the personal and technological standards students need to meet to be considered for careers as service technicians.

Personal Skills

Personal Abilities and Traits

Students will demonstrate the ability to:

- Repair a piece of equipment or an assembly requiring them to work in a physically awkward or difficult position according to the same standards they would achieve in an ideal location.
- Repair cheerfully and successfully a piece of inoperative equipment when the customer is very disturbed or angry.
- Complete a series of tasks requiring them to work alone for eight hours, just as they would under someone's direction.
- Accurately follow each and every step in a long adjustment procedure.

Interpersonal Relations and Communications

Students will demonstrate the ability to:

- Use clear, concise and technically accurate language to explain to a co-worker how to make a particular mechanical, electrical or pneumatic adjustment so that the co-worker can make the adjustment correctly.
- Answer a salesperson's question about equipment operation accurately and clearly, in a positive manner.
- Present effectively to a supervisor their positions in conflicts with customers, co-workers or salespersons.
- Prepare clearly, concisely and accurately a job application and a resume.

Mathematics

Basic Mathematics

Students will demonstrate the ability to:

- Add and subtract accurately.
- Multiply and divide accurately.
- Calculate powers of ten.

Units of Measure

Students will demonstrate the ability to:

- Measure with a common rule (English or metric) to the tolerance of the scale being used.
- Convert, making no errors, fractions to decimals and decimals to fractions.

Computers

Students will demonstrate the ability to:

- Add and subtract correctly in:
  1. Binary,
  2. Octal, and
  3. Hexadecimal
- Convert numbers from one base to another without error.

Basic Mechanics

Students will demonstrate the ability to

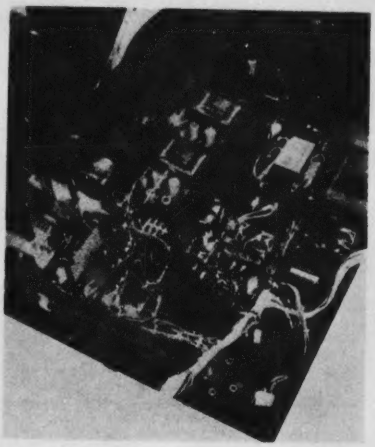
- Understand how levers, gears, chains, sprockets, belts and pulleys are used to increase or decrease the mechanical advantage and speed of motion
- Adjust solenoids for proper operation
- Adjust micro switches for proper overtravel and release
- Adjust tension properly on belt and chain drives, with and without idlers
- List the proper lubrication of the following parts under conditions of light pressure, heavy pressure, high temperatures and low temperatures
  1. Gear boxes
  2. Oilite bearings on shafts
  3. Plastic bearings on metal shafts
  4. Plastic to plastic
  5. Metal to metal
- Identify defective parts among the following and describe the cause and result of their condition
  1. Relay contacts
  2. Motor brushes
  3. Motor commutators
  4. Pins (sockets in connectors)
  5. Broken wires (hidden by unbroken insulation)
  6. Frayed wires
  7. Frozen bearings
  8. Stretched chains
  9. Bent levers
  10. Bushings
  11. Scored shafts
  12. Bent shafts
  13. Out-of-round shafts
  14. Gears
  15. Broken teeth on gears
  16. Sprockets
  17. Deformed springs
  18. Pulleys

Fastening Devices

- Identify and provide examples of the use of the following types of screws
  1. Machine
  2. Sheet metal
  3. Fine metal
  4. Coarse thread
  5. Self-tapping
  6. Setscrews
  7. Capscrews
  8. Hex head
  9. Allen head
  10. Flat head
  11. Thumbscrew
  12. Fillister head
  13. Phillips head
- Identify and provide examples of the use of the following pins
  1. Spiral
  2. Dowel
  3. Tapered
  4. Roll
  5. Cotter
- Remove each of the following types of pins and keys so that it can be used again

Pins	Keys
1. Spiral	1. Square
2. Dowel	2. Woodruff
3. Tapered	
4. Roll	
5. Cotter	

- Remove and install each of the following types of rings
  1. Truarc (inside and outside)
  2. E-rings
  3. O-rings
- Remove and install the following types of nuts, giving reasons for their use
  1. Hex
  2. Jam
  3. Castellated
  4. Wing
  5. Cap
  6. Thumb
  7. Stop
  8. Tinnerman
- List the problems that would result from stripped and cross-threaded screws and nuts



Soldering

Students will demonstrate the ability to:

- Remove and replace an integrated circuit (IC) on a printed circuit board using the following equipment:
  1. Vacuum and desoldering tool
  2. Solder braid
  3. Heat sinks
  4. Flux cleaner
  5. Solder irons (different wattages)
  6. Choice of fluxes
  7. Choice of solders
  8. Tip cleaning equipment
- Perform the foregoing repair so that:
  1. the foil on the circuit board is intact,
  2. the IC tests properly; and
  3. the circuit board does not show any burn spots or cold solder joints.
- Remove and replace soldered wire connections to plugs and circuit boards.
- Make "in-line" soldered splices on wire harnesses.

Mechanical Drawings

Students will demonstrate the ability to:

- Describe the function of a mechanical device pictured in a cut-away drawing.

Safety

Students will demonstrate the ability to:

- Use properly functioning tools and test equipment in a safe and effective manner.
- Use the proper technique for lifting and moving heavy equipment.

Electronics

Basic Electronics

Students will demonstrate the ability to:

- Solve simple electrical circuits using Ohm's Law.
- Solve for resistances, voltages, currents and wattages in series, parallel and series-parallel electrical circuits using Ohm's Law.
- Measure currents and voltages in AC circuits containing resistance, inductance and capacitance.
- Define common base, common emitter and common collector transistor circuit characteristics.

Electrical Symbols and Diagrams

Students will demonstrate the ability to:

- Match a specific point on a schematic representing an electronic circuit to its part on the electronic component:
  1. Anode of the diode
  2. Base, collector, and emitter of the transistor
  3. Gate of the triac
  4. Specific pin (i.e., pin 3) of the IC
  5. "Clear" or "reset" input to the microprocessor
- Follow a signal from start to finish on schematics representing more than two different circuit boards.
- Determine points where signal flow can be checked on circuit boards.
- Describe the condition and purpose of each of the following active devices on a schematic with signal inputs:
  1. Diodes
  2. Transistors
  3. LED's
  4. SCR's
  5. Triacs
  6. Zener diodes
  7. Relays
  8. Microswitches.

Logic Circuitry

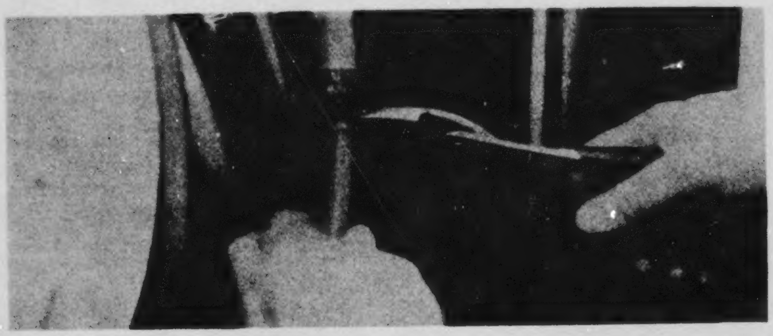
Students will demonstrate the ability to:

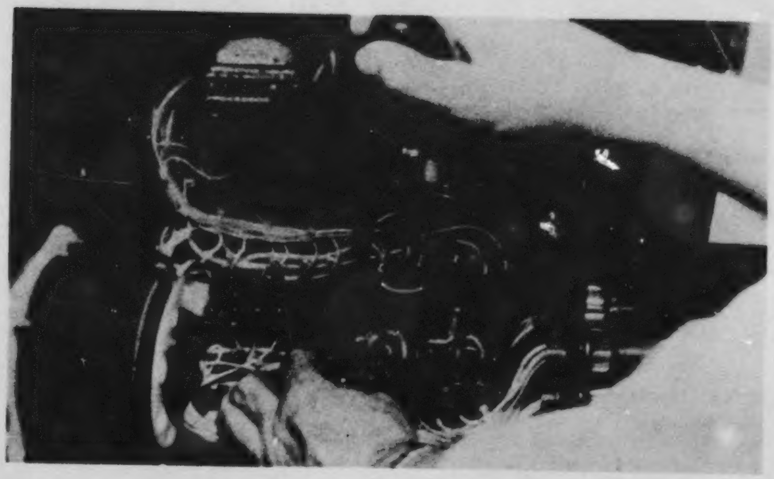
- Wire and verify the input and output circuitry of logic gates, using truth tables.

Block and Timing Diagrams

Students will demonstrate the ability to:

- Define the uses of electrical and mechanical block diagrams.





Tools and Test Equipment

Students will demonstrate the ability to select and use the following tools to complete a variety of mechanical tasks.

Hand Tools

1. Tightening
   - A. Box and open-end wrenches
   - B. Hex wrenches
   - C. Ratchet-drive socket wrenches
   - D. Slip-joint pliers
   - E. Needle nose pliers
   - F. Screwdrivers
2. Cutting
   - A. Hacksaw
   - B. Files and file card
   - C. Wire cutters
   - D. Wire strippers
   - E. Abrasive cloths
3. Drilling
   - A. Drills
4. Measuring
   - A. Dial indicators
   - B. Thermometers (temperature gauges)
   - C. Feeler gauges
5. Soldering
   - A. Soldering irons (different wattages)
   - B. Heat sinks
   - C. Solder braid
   - D. Desoldering tools
   - E. Tip cleaning equipment
6. Other
   - A. Center punches
   - B. O-ring removal tool
   - C. Hammers
   - D. Mirrors
   - E. Spring hooking tools
   - F. Pin extractor (electrical plugs and sockets)

Power Tools

1. Electric drill
2. Electric grinder.

Electronic Test Equipment

Students will demonstrate the ability to use the following test equipment to make specified measurements:

1. Oscilloscopes
   - A. Frequency
   - B. Pulse width
   - C. Amplitude
   - D. Signal relationship (dual-trace scope)
2. Volt-ohmmeters
3. Digital voltmeters
4. Ammeters

Parts Handling

Students will demonstrate the ability to:

- Arrange for storage the following parts so that each part can be located easily and promptly by means of a filing card system:
  1. Shafts (2 to 24 inches)
  2. Bearings (oilite, ball, plastic block)
  3. Circuit boards
  4. Glass items (lamps, mirrors)
  5. Lubricants
  6. Small electronic parts
  7. Hardware (screws, bolts, pins, keys, and rings)
  8. Rollers (2 to 24 inches)
  9. Seals—gaskets
  10. Plastic parts

Reporting and Record Keeping Administration

Students will demonstrate the ability to:

- File (alphabetically or numerically) and retrieve rapidly an assortment of technical data.
- Add new data to or purge out-dated or redundant information from a well-organized file or collection of technical data, remaining able to locate with minimum delay any bit of pertinent information.

Reports

- Complete an accurate time and activity report for a hypothetical workweek.
- Fill out an order form for parts needed next month, using a list of parts used over the last year, a list of recommended parts to carry, and a list of parts on hand.
- Fill out accurately machine service history logs, using correct technical terms.

Map Reading

- Find a given location on a map of a city.
- Indicate the best route to a given town on a state map marked with a starting point.

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Mr. **Fuqua**. Thank you very much. We appreciate all of the testimony from the witnesses.

When Dr. Keyworth testified before the committee, he said that science was entering an era of maturity and that we were going to have to establish our priorities in a different fashion. I assume that included research, where we did it, and the manpower needs. There are those who think that we need to spend more money in those areas, similar to the post-World War II period and the Sputnik period. What advice do you give us on this dilemma that we are faced with, Dr. Saxon?

Mr. **Saxon**. First of all, I think that the dilemma you address is a central one. In your opening statement you referred to it, and I agree completely with that.

I am not, however, totally discouraged by the present situation, despite our problems. The reason is that I believe there is really quite broad and general recognition throughout the Government and throughout our educational system of the true nature of the problems we face. I see nothing in Mr. Keyworth's statement which indicates any lack of understanding of what those issues are.

I think, however, that there has been perhaps insufficient appreciation of the fact that certain actions being taken by the Government in order to bring spending under control are having adverse consequences, but I do not think the savings are all that large, if you look very carefully at it.

I am particularly concerned about the fact that, as my two colleagues from industry have indicated, we are dealing entirely inadequately with the support for and the environment in which graduate students are going to study and be produced. I fear that the long-term consequences of that inadequacy will be quite dreadful.

In a way, we can understand that by what is happening right now in engineering and computer sciences, because the roots of that problem go back about a decade or so. I think all of you remember that a decade or so ago it was widely believed that we were overproducing people in engineering, and therefore an effort was made, with Government leadership, to cut back on the number of engineers produced.

But this process of cutting back has long term consequences associated with it. That affects what happens in high schools; it affects what happens when students enter college; and finally, 10 years later, you find you are not producing enough engineers. I think we need to understand those kinds of connections.

There is a certain similarly disconnected aspect to the administration's policy. On the one hand, it believes in and understands the Government's role in supporting basic research, but it does not quite see that other things it is doing are going to adversely affect our ability to carry out basic research over the long haul. I think we need to hit very hard at that and try to spell out the long-term consequences I mentioned.

I am very encouraged by the work of this committee, and I think there are many of my colleagues who would be pleased to try to lay out the problem in greater detail for you. I am also encouraged by the fact that I doubt anything you have heard today, or in previous testimony, has come as a surprise to you.

In short, I think the problems have been identified. We know what they are, collectively. The question is, Do we have the will and the capacity to deal with them? Given their importance, I am confident that we can, not that we will, but that we can.

Mr. **Fuqua**. David, one of the concerns that I have had—and you have touched on it in your testimony—is that the people who support the Gas Research Institute, and others like EPRI, and others who are funded by regulated industries—that for them the rate base has been such that it may have some adverse impact on their ability to continue to fund research at the present level and also pick up the difference, or part of the difference, between what the Federal Government had been funding and what you are funding from private sources. I hope I am making myself clear. Could you comment on that?

Mr. **Webb**. Yes, Mr. Chairman. I think what you said is correct.

I know in our industry particularly nearly everyone supports the idea of trying to reduce the level of Federal expenditures. It seems to me the biggest problem is making the blanket assumption that when you make these budget reductions, the response capability—of the technology base and the financial resources are uniform across all segments of industry.

So if you make that blanket assumption, then you are building in a lot of severe consequences if you try to apply that without recognizing the differences between regulated versus nonregulated companies that have had a strong technology base for years and those that have not.

What is going to happen in the case of the gas industry and the gas technology base is this: Our board, and I think the other member companies that fund their own research outside of GRI, are going to step in and, as best we can, fill the void in the near-term research. We accept that as a legitimate challenge to the industry; in fact, it should be done. But we cannot simultaneously do that in the regulated environment in which we work and also pick up the long-term research we had assumed would be continued by the Government under their pronouncements.

So the consequence is—and what I am trying to make the committee aware of—if you decide not to do that, do it with the knowledge it means the research will not be done, not that somehow, magically, industry is going to step in and do it, because in the regulated segments the transition period is over several years, not several months.

Mr. **Fuqua**. Thank you.

Mr. Brown?

Mr. **Brown**. Mr. Webb, can I continue with a question? First let me say that I have been very pleased with the development of the industry-wide approach to sharing R. & D. costs as represented by the Gas Research Institute as well as EPRI and other similar things. The utility industries, both gas and electric, are fortunate in one sense, in having a very large base of consumers. That is, in effect they represent the people of the United States; they serve the people of the United States.

I am sure you will recognize that many of the decisions being made now with regard to the funding of R. & D. are basically political decisions, at least in the sense that they are subservient to overall budgetary or other political goals.

My question to you is, recognizing that, has your industry considered the significance of gaining consumer support for the kind of expanded R. & D. program that is necessary for your industry and which you could probably achieve from some relatively simple system of including a public or consumer input to your GRI board or policy operators in some fashion? You may already have done that, but I would like to ask you to comment on it.

Mr. **Webb**. Yes, Mr. Brown. The Gas Research Institute, the way it is structured—and it is part of the requirement, going through the formal rulemaking process before the Federal Regulatory Commission—we have three major ways in which consumer interests now come into GRI. One is just the formal rulemaking process itself, where anybody can intervene if they do not like the program we are proposing and request a hearing as it goes through the regulatory process. That is kind of removed, from the consumer, but it is there.

The other is our advisory council, which is a senior policymaking advisory body to GRI and actually participates in our board and has two members at large on our board of directors. At this time they are Bob Georgine, president of the AFL-CIO Building Trades Union, and Larry Moss, who was a past president of the Sierra Club.

On that advisory council there are eight sitting State public utility commissioners, one of which must always be the chairman or the vice chairman. There are representatives from the labor movement, the environmental movement, from academia, and then the broad public interest group. So we do that.

The other part of the program we have is that we go to the different States and participate when our member companies are applying for rate bases and brief the State commissions and the consumer groups on GRI and our program. This appears to have been successful.

I realize that there are probably other steps people could recommend and we would consider, but by putting people on our board who, in fact, represent the consumer interest and by having State regulatory commissioners on our advisory council, and then the protection that the public is ordinarily accorded through the formal ratemaking procedure for a regulatory body, it seems to me the consumer interest is there.

I think our record speaks fairly well for itself in that there has not, to my knowledge, been opposition to the GRI program. As the GRI gets larger, I think that will tend to change, because the larger you get the more vulnerable you are, and people are saying, "Why are you doing research in this area, when we don't think it is in our direct interest or our direct benefit?"

Mr. **Brown**. I think the steps you have mentioned are all extremely reasonable, but it is obvious to me that we are going to have a lot of significant policy issues in this session and in the near future dealing with utility issues. The Alaskan pipeline deal that we voted on in December is a classic example.

What I am talking about is ways in which there can be greater public awareness of the need for a coordinated energy policy and the significance of gas in this coordinated policy. I think you need to build on the steps you have already taken to achieve that. I will not belabor that. I am just making that as a suggestion.

Dr. Saxon, you have made a related point with regard to the need for a coordinated policy in the R. & D. field and mentioned the recommendations of the National Commission on Research. I should be familiar with that, but could you just elaborate briefly for the record on those recommendations?

Dr. **Saxon**. The National Research Commission recommended the establishment of a forum—that was the word they used—which would have as its function the discussion and formulation of policy in these areas.

In addition, the National Academy of Sciences has appointed a committee to study the question of university and Government relations with respect to the support of science.

It has three subcommittees, one of which is now addressing the question of organizing such a forum—trying to identify the kinds of people who would serve on it; trying to identify the kinds of issues it would discuss; and, perhaps the most complicated of all, trying to identify its sponsorship.

It cannot simply be an arm of Government, obviously. On the other hand, it cannot serve any useful purpose if it is totally disconnected from Government, and they are struggling with that—what are the appropriate kinds of sponsors? What is the role of the National Academy of Sciences? What about the American Association of Universities, the AAAS, or the National Science Board? These questions are now being pursued with some vigor. We hope to have, by spring, further development of that particular concept. If you were to get in touch with the academy people, they could tell you the current status.

Mr. **Brown**. Yes, I will do that. Thank you.

Mr. **Fuqua**. Thank you, Mr. Brown.

Mr. Flippo?

Mr. **Flippo**. Thank you, Mr. Chairman.

My good friend and colleague from California, Mr. Brown, made the statement—and I agree—that R. & D. policy seems to be subservient to other political considerations in budget terms and that sort of thing. You gentlemen are being very kind in pointing out some areas that we need to consider and evaluate in trying to help determine a national science policy.

I noted with great interest, Dr. Saxon, that you and Dr. Press both address the area of geographical distribution of funds and seem to be saying that it is a factor that should not be included in the evaluation of national science policy.

In a sense you seems to be saying, "Cut that other fellow, if you are going to cut funds, and fund the best universities." That seems to be rather reinforcing, because certainly the best would then obviously get better. It seems to be denying the mobility of research.

I think that Congress, as a national policy, and the administration as well, ought to be interested in geographical excellence. You make the statement that excellence should take precedence over political and geographical considerations. The reason that it has political consideration is fairly obvious—the economic activity that comes around the universities from the R. & D. is very clear. The growth of industries in computers, in aeronautics, in communications, in electronics, clearly comes from the Federal R. & D. effort, and it seems to me that a major part of a national policy ought to be in favor of geographical excellence as well.

I am not trying to say that funds ought to be distributed solely on that basis, but, first of all, the statement seems to assume that we already have a policy of allocating funds based upon geographical considerations, and I would deny that. I would point out that the NSF 1980 allocations clearly show, as one example, that we do not now have a policy of geographical distribution of funds, and to say that that ought not to be a consideration seems to me to not be too good advice at the present time. Would you care to comment on that?

Dr. SAXON. Yes, that is an issue whose importance, and sensitivity I understand. Therefore, my remarks were not made lightly.

I will not, of course, try to speak for Dr. Press, but let me try to explain my concern. If I had been appearing before this committee 2 years ago to talk about this, the question of geographical distribution of research support would not have been a part of my statement.

The first thing you need to understand is that today's context and environment are quite different from what they have been in the past. Indeed, there was a systematic effort over quite a number of years on the part of the National Science Foundation and others to take positive steps—affirmative action, if I could put it that way—to produce excellence across the country. The centers of excellence program was an example. Very large development grants were made to universities which were seeking to become excellent.

I had no disagreement with that; I thought that was a sound idea. In short, the notion of making excellence available everywhere in the country—and I did read your comment on that subject—is one that I would support. But the present environment is one in which Dr. Keyworth is saying we need to look at our current programs, and we need to cut.

I am not sure I agree with that, but I think it is going to happen. I am emphasizing that, if you are going to cut back on support for science, you had better be very careful not to let geographical considerations, which have a lot of political clout associated with them, dominate that cutting process.

Just read the newspapers and see what happens when someone wants to close a shipyard somewhere or an elementary school somewhere, and you will see what I mean. There is quite a difference between the two processes of expansion and contraction. When you are adding funds with the explicit aim of producing excellence everywhere, that is one kind of undertaking, and I supported the effort to help institutions improve the quality of their research. On the other hand, when you are trying to cut back and trying to determine what has to be cut, then I think the considerations are rather different.

I say this because I am very concerned that, as one tries to scale support down—and I am not sure it ought to be scaled down—these considerations may indeed dominate, and I think that would be a very serious error in the long term.

Mr. **Flippo**. I appreciate that, and it is an issue that continues to cause a great deal of controversy. But if there has been an affirmative action program to accomplish that in the past, the statistics would indicate that that action failed, I believe. But I realize that others may have different opinions on it. I just thought that it ought to be, because of its economic importance to the various sections of the Nation, one of the factors to be considered.

Dr. **Saxon**. May I make one other comment, with your permission? I think to say that it failed is perhaps to overstate it. To say that it did not entirely succeed is, however, correct. In other words, if you look at that program, you will find that there have been quite successful consequences of it—quite strikingly successful consequences—but you will also find that it turned out to be enormously more difficult to do than people had imagined.

I do not think it was less than entirely successful because people did not try. There were, in fact, very substantial grants given to quite a large number of universities around the country, but the realization of the perceived potential for excellence in many cases did not follow. It turned out to be a very difficult problem. The failure was not because people did not seriously try.

Mr. **Flippo**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Flippo.

Mr. Dunn?

Mr. **Dunn**. We have been talking about impacts of budget cuts. None of us has seen the 1983 numbers yet. The groups you represent did, nevertheless, take cuts last year and are anticipating more cuts next year. What if I could say to you that we will guarantee you a 20.3-percent increase? How would you feel?

Dr. **Saxon**. Terrific.

Mr. **Dunn**. Would you feel you had been singled out for special care in lieu of what else is going on in the Government?

Dr. **Saxon**. Is that addressed to me?

Mr. **Dunn**. Anybody.

Dr. **Saxon**. It seems to me that the administration's analysis and policy—and the word policy is related to the word political—involve an effort to sort out those things that it is appropriate for the Government to support and those which it does not find appropriate to support. That sorting out is taking place, and it is one dimension of what is going on. The other dimension is an absolute cut-back in the total level of Government involvement and Government expenditures.

So within that framework there are manifestly differential treatments on the part of the the administration. For example, defense has been already singled out as an area where support can only come from the Federal Government. Neither the States or the private sector is going to provide it.

The same statement has been made about basic research—that it is something you cannot expect the private sector to support; you cannot expect it to be supported on the scale required in any other way than by the Federal Government. It is in that context, I think, that I would myself put these considerations.

Mr. **Dunn**. But you would agree that a 20.3-percent increase would be a nice thing to have?

Dr. **Saxon**. That is your number.

Mr. **Dunn**. No, I am saying, if I could guarantee a 20.3 percent increase.

Dr. **Saxon**. I would feel rather pleased about that, yes.

Mr. **Dunn**. You have been talking about cuts in the administration. You should be aware that the majority on the other side of this committee have just recommended a 20.3 percent increase for themselves this year. Mr. Flippo used the words, "Cut the other fellow." You ought to, when you are listening to the rhetoric on this committee, be aware of who the other fellow is. That 20.3-percent increase just recommended by the majority of this committee for this committee amounts to $343,000.

You have been talking about engineering students. The chairman and I are both concerned about graduate engineering students. I wonder if a better use of that $343,000—and our research seems to indicate that there is about a $7,000 spread that would be necessary to maintain graduate students—if we divide $7,000 by 343, would it not be a better use of committee funds to give that to 50 deserving students this year? What would you think of that?

Dr. **Saxon**. I'd say I am not dumb enough to answer that question. [Laughter.]

Mr. **Dunn**. I think I have made my point about campaign rhetoric, political rhetoric, and who is cutting whom. I thank the chairman.

Mr. **Fuqua**. Thank you, Mr. Dunn.

Mr. Winn?

Mr. **Winn**. Thank you, Mr. Chairman.

Mr. Webb, it would appear that as Federal R. & D. funding is decreased, GRI funding with industry participation is taking up the slack at the present time. To what extent is GRI prepared to carry out this trend? You touched on it, but you did not tell us how far they were going to go or if they were going to go much further, and if the Federal funding is totally eliminated—that is the bottom line—what would happen to the total R. & D. efforts.

Mr. **Webb**. Mr. Winn, we are prepared to pick up as much of the near-term as we can within a reasonable growth rate, so that it can be managed. In other words, it does neither the country nor the gas industry any good to increase our budget faster than we can actually properly spend the money. That does nothing but take dollars from the ratepayer and essentially waste them.

So within a manageable growth rate, we are stepping up in the near term. We are going from an R. & D. budget of $83.7 million in 1982 that has been approved by the FERC to approximately $118 to $120 million of research in 1983. We are talking about real growth in the next 3 or 4 years, probably of $15 to $20 million a year in real growth above the inflation rate as a long-term goal for the institute. The areas where we will not be able to pick up the research are the long-term, high-risk areas such as geopressured methane, in situ coal gasification, and some of those areas, for the simple reason we have two charters.

No. 1, we have a constituency—that is, the ratepayer—and it is hard for them to recognize a payback from something that is 20 or 30 years in the future. That is beyond their planning horizon, beyond the horizon of which they are going to support the Gas Research Institute. Second, the regulatory community is insisting that there be some reasonable chance of a payback within a reasonable period of time to the ratepayer.

Therefore, it seems legitimate that we step into the near-term role. I just think there are some legitimate long-term research areas at some funding level that is required over the next 10 or 15 years as we make a transition from gas produced, from drilling a hole in the ground, to gas that is through some kind of a conversion process, whether it is coal, biomass, or whether it comes out of tight formations.

Mr. WINN. You mentioned the long-range planning. You used that term several times in your testimony. You did again just now. In reference to the cofunding research projects, you mentioned the long-range commitment by DOE. What does that mean, particularly under the present authorization and appropriations procedure, and what is it going to mean under the possible phase-out of DOE?

Mr. WEBB. Up to now we have had a good relationship and have been able to sit down with the Department, saying, Here's our budget over the next 5 years. We submit a 5-year and an annual program each year that is updated to the regulatory community.

Before we develop that program, we sit down with the other Government agencies here in town that also fund gas-related research and try to determine cooperatively the areas they are going to be funding, so we can try to target our research dollars into those areas we think are important but the agencies are not funding.

With the change in philosophy, obviously the cofunding levels we were projecting—and they are not just numbers pulled out of the air, they are numbers that are derived after discussing with program managers in the Federal agencies what they had anticipated will change. The 1983 numbers, for instance, were derived from the 1983 numbers presented in the 1982 budget by the administration.

If the funding cutbacks they are now talking about are, in fact, recommended and approved, then obviously the long-term cofunding with the Department of Energy does not mean anything, because the Department of Energy is not going to do gas-related research. That means for a period of time, while there is a transition, the research is just not going to be done—the long-term, high-risk research.

Mr. WINN. Thank you.

Dr. Saxon, do you believe that the federally-sponsored R. & D. funding has inhibited industrial sponsorship?

Dr. SAXON. I do not think so, although I suppose one could argue that it takes some pressure off industry in that regard. It is not my perception that in this area industry is dominantly influenced by what Government funds. I think it is much more influenced by tax policy.

Mr. WINN. I was just going to ask that.

Dr. SAXON. Tax policy, I think, is very important. The point about industry support, of course, is that it is based on perception and understanding of how industry is going to benefit. I think where it is clear that they will, then they are going to go in whether or not the Federal Government is involved. I have not seen that as a barrier, but the tax policy is quite a different matter.

Mr. WINN. I am interested in your comments about the laboratories. If the industry is to make more use of the national laboratories' facilities, how do you recommend that we overcome industry's concerns about proprietary information, Federal patent laws, and the limitations of the Department's contractual regulations?

Dr. **Saxon**. I think it is essential that we do in fact resolve some of these concerns, because unless we do, it is going to be very difficult to get significant participation. The Government has been, generally speaking, much too protective of its interest, superficially perceived, in connection with patents. I believe that experience within universities and industry shows that the Government policy is not so much protecting patents but preventing patents from ever getting filed, preventing these works from going forward.

There are a lot of ideas which have simply not been developed as much as they could be, and I would submit that the public interest might be far better served by opening this process up, by worrying less about the potentiality for commercial gain on the part of people whose work has been carried out with Government sponsorship. That is not a bad thing as long as it is done in an open, understood way, and I do think that patent policy, licensing policy, and these other questions need to be addressed from that perspective.

On the other hand, it is important for people to recognize that where they are dealing with national laboratories on programs which are intended to provide information and techniques for a whole industry, that is a case in which they should not worry so much about proprietary interests.

Mr. **Winn**. I know my time is up, but this committee spent quite a bit of time last year trying to address this problem, and I am quite sure it is going to come up somewhere, somehow, again this year.

Dr. **Saxon**. There has been progress, of course, and we very much appreciate that progress.

Mr. **Winn**. But it is a problem with industry, too.

Dr. **Saxon**. Yes.

Mr. **Winn**. Thank you very much, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Winn.

Mr. Lujan?

Mr. **Lujan**. Thank you, Mr. Chairman.

One of the concerns that the committee has had for quite some time—and it was brought up under the questioning by Mr. Dunn, and the chairman last year had some amendments to encourage young people into the engineering science field. I think that is a big problem that we have. What could we do to motivate young people to go into those fields?

The easy answer is more money, scholarships, and those kinds of things. I am thinking in terms of exciting the teachers somehow in high school and junior high to have the kids begin to look at that kind of a career.

Dr. Saxon, could you address that? How did you happen to go into the field that you are in? Was it a scholarship? How can we get this moving?

Dr. **Saxon**. The question you raise is one of the most challenging and important that we face as a nation. I think it is a problem that has to be dealt with in every State and in every municipality of this country. In my view, it has to be attacked at every level simultaneously.

The worst thing you can do is to somehow treat it as a problem so large that, if something hasn't been done by the time a student reaches the first grade, nothing can be done at all.

Furthermore, I think we need to deal with it at every possible level right now. We need to encourage students presently entering college to go into careers in science. That may mean we need to provide them with special opportunities to increase their mathematics skills. If they come in with some deficiencies, we need to provide ways for them to overcome them. We need to encourage people who are now finishing college to go on into graduate school.

At my university we have just taken the unprecedented step of providing new salary scales for engineers—and computer scientists as well—which are at a higher level than those of their colleagues. Their colleagues are not delighted about this, but we felt it was absolutely essential to do, because we cannot educate people without the faculty, and we cannot get faculty in these disciplines without competitive salares. That is one way in which we can work at the problem. Our university is also working with students in the high schools and in the junior high schools to encourage them to think about college and to take the right courses.

Mr. LUJAN. I think the teachers—if they are excited about it——

Dr. SAXON. We are working with teachers, and right now we have an effort going in our State which is intended to make explicit what it is that youngsters need to know if they are going to succeed in college, what kind of education they have to have. We are starting that at the seventh grade level. We are working with teachers, PTA's, and all such groups. Those are things that require something other than money.

On the other hand, I think it is also important that we provide the kind of support that makes it possible for young people to pursue those kinds of careers, and, I repeat, we need to attack the problem at various levels simultaneously.

Mr. LUJAN. Let me get on to a question that may not be quite fair, but we sit as Members of Congress, and at least I view the big problem that we have in this country as expenses running away—the interest rate, the inflation factor. That affects research and affects your operation of the universities, associations, and companies. So we are looking at how do we handle this big, big problem of the inflation, interest, and all those things going up.

The President's proposal, in which I concur, is to try to keep Government spending at a modest level. That is not saying cut, for example, in expenditures for research. I am looking at a chart here from 1960 through 1981 [indicating chart]. It keeps going up. That is constant dollars [indicating]; this is adjusted for inflation [indicating]. Of course, that is the problem. If we can reduce the inflation, then those two lines will be together.

But we sit here, and our basic responsibility, I guess, is to try to bring those influences down. As I said, maybe it is not quite a fair question, but here we are talking about the research budget under stress. All budgets are under stress.

When somebody from a hospital group comes in to see me and they are in town today, or education people—the school boards are in town today—my question is, "Well, if we don't cut you, whom do we cut?" I will ask you the same question. You are certainly not going to say the aged, the hot lunch program, the social security, or any of those. But cuts need to be made.

Dr. **Saxon**. That is a very difficult and serious question that obviously needs to be considered. I know that your chairman, in his opening remarks to these hearings, pointed out that self-serving and untempered requests were not going to be well regarded. I am quite aware of that.

In a way, I think one has to put it in the same context as Mr. Webb put his comments. In other words, one needs to understand the consequences of actions that are being taken. It is the case at the moment that the administration has decided that in the defense area, for example, even though the Federal budget needs to be cut, there are other pressing considerations. The same statement has been made about social security.

What is involved, as you well know and as your chairman also pointed out, is that two kinds of actions are taking place simultaneously, which are not always internally and mutually consistent. On the one hand, an effort is being made to scale back the cost of Government, to scale back its cost and its involvement. There is a coherent political program associated with that, and it is intended to address, among other things, the issue of inflation.

Mr. **Lujan**. It affects research also.

Dr. **Saxon**. Yes, research is a part of it; that is correct.

In the sorting out of what is and isn't appropriate for the Federal Government to do, there are two elements involved. Some things, the argument goes, ought to be done at the local level; others ought to be done by the private sector.

But basic research has been specifically identified by this administration as an area which cannot be handled by either of those jurisdictions. It has been explicitly recognized as an area where the Federal Government must provide the basic levels of support. I agree with that; you all agree with that. It has also been explicitly stated that basic research is absolutely indispensable to our productivity which is, over the long haul, going to solve the problems you refer to.

Now comes the question. If you are going to cut back, then I think you have to recognize the consequences. You are going to have to recognize that hobbling basic research will work against just those goals the Federal Government has said it wants to attain. It is quite a different matter from cutting back on food stamps.

The argument being made in the case of food stamps is that yes, it is very difficult for people now, but long-term, by increasing productivity, by reducing inflation, we are going to make everyone better off. That is the argument. So there is a long-term purpose being served by some of the hard cuts that are being made. The long-term purpose with respect to basic research is the opposite. That is the reason I think this needs to be looked at very hard and very carefully.

Mr. Chairman, as I read your remarks and also Mr. Flippo's remarks, it seemed to me that both of you were saying just that. There is a special dilemma here, not a cruel one in the sense of dealing with the aged or the poor but a dilemma nonetheless in terms of the long-term needs of the Nation. That is what I read into your statements, and I think there is general agreement about that dilemma. It is a very tough issue.

Mr. **Lujan**. Thank you.

Mr. **Fuqua**. Thank you, Mr. Lujan.

Ms. Schneider?

Ms. **Schneider**. I will give Dr. Saxon a rest for a minute. Mr. Webb, I would like to ask you this: You had mentioned possible GRI efforts to increase R. & D. cofunding with industry. I wonder if you could be specific and tell us what industries were involved with cofunding research?

Mr. **Webb**. Yes, ma'am. Most of our increased funding with industry has primarily come from the manufacturing segment, where we have developed through research a process that the manufacturing sector can become involved in to try to develop a product they can take to the marketplace.

So primarily it has been in the area of appliances, where we are working with several manufacturers to develop products—a pulse combustion furnace is one example. In exchange for the background patent rights developed under our research, the manufacturer comes in and puts in some dollars as well as his engineering time to develop the product. We give them an exclusive license for 3 years, so they have an incentive to market it. In exchange for that, we insist on a royalty payback, so we can try to reduce the cost of our research in the future.

We are beginning to get quite a bit of increased cofunding in the manufacturing sector. In the past gas traditionally has been so cheap there was no incentive to use it efficiently. When it was only 2 or 3 percent of the total cost of the product, the incentive was to build the cheapest device possible to use the gas, not the most efficient. We are beginning to see quite a bit of cofunding in those areas. We still get some cofunding from the Department of Energy, but it is beginning to be a very, very insignificant amount of money.

We are not getting much cofunding in the production side, because most production in the gas industry is done by the oil companies. We represent the regulated segment, and the oil companies, I think, still produce 89 percent of all the gas that is transported through the regulated segments of the industry. So nearly all cofunding is in the efficient utilization side with the manufacturing sector.

Ms. **Schneider**. If natural gas were to be deregulated tomorrow, would you change your comments insofar as commitment to only near-term research to incorporate investment in long-term research also?

Mr. **Webb**. No, it would probably put greater pressure on us to increase the near term. The reason is that the economic rent from decontrol goes to the producers. That is the oil companies; that is not the regulated gas industry. So what you have is the price of gas going up faster than competing energy commodities, which means there is more and more pressure to try to use it more efficiently so you can still compete in the marketplace.

What it would do to our program is this: I think you would see us have to increase our budget primarily in the industrial sector faster than the other parts, because there is probably 1 million barrels per day of oil equivalent out there that can switch in 60 days from gas to oil, depending on the economics. They have a dual-fired capacity. So there would be a tremendous increase there, but not in the long-term research. I think it would skew it more toward the near term, is what I am trying to say.

Ms. **Schneider.** OK. Thank you.

Dr. Saxon, I noticed in your written testimony that you mentioned the importance of equal opportunity in education and the importance of utilizing all of our human resources. I wonder if you could please elaborate on the effects the budget cuts will have, for example, on women and minorities, who are only of recent years becoming involved in these areas of educational pursuit?

Dr. **Saxon.** I think the most immediate impact is likely to have to do with the cuts in student financial aid, as it is called—the support for students who are attending universities. As that aid is cut back, the pressure is going to be felt most keenly by those who are least able to afford education for themselves.

I think that is inevitably going to mean that people will attend lower cost institutions. That does not necessarily mean institutions with lower fees but institutions closer to home, because the major costs of education often are the costs of living away from home.

So we are going to see a great movement of students into their local institutions, and that often means community colleges, and therefore we are going to see in our cities more minority students attending their own local community colleges and fewer being able to go to the universities. That is an unfortunate and immediate effect, but that is my prediction.

With respect to women, I think these economic factors are obviously not related to sex, they are related to quite different matters. I do not see the same impact on women.

Ms. **Schneider.** But specifically in the areas of science and engineering and investment of the research dollars into that, does the University of California, for example, have any plans or programs in mind that they might use to make it a little easier for minorities or women to get into those fields? More often that not, when the budget cuts do occur, those individuals who are traditionally in a field will be the last to feel the budget cuts.

Dr. **Saxon.** That certainly is a concern. The programs we have in place which provide, at least in the educational sense, facilities which are especially useful to women in mathematics, engineering, or the like, are dominantly from State funds rather than Federal. So that is a problem for us, because our State budget is also being squeezed. But I think you probably have enough trouble without my bringing that one in.

Ms. **Schneider.** We have had testimony before this committee earlier this year, or last year as a matter of fact, and it was rather discouraging to find that many of the comments made by scholars were that we are something like 13th in the world insofar as graduating engineering students is concerned. Part of the concern there was that now the students are living on their own, they are more anxious to go out and get a job, and not interested in pursuing or furthering their careers through graduate school.

It seems to me that as the Federal Government is getting out of many different education programs, No. 1, they are not going to be able to fund the microscopes, the different technological assistance machinery, or whatever, that they might have in schools to help students. So it seems that there will be increased pressure on industry to assist the institutes of higher learning to focus on specific ways of attracting students.

Dr. **Saxon**. I agree with that There are problems, however. The studies of obsolescence of equipment go back 2 or 3 years. Obsolescent equipment is not the consequence of new Federal policies; it is the consequence of a process that has been going on for a number of years. We are trying very hard to modernize our laboratories. That is hard to do. Our facilities are antiquated.

But those deficiencies do not fall with an uneven hand; they fall evenly on all students. They make it more difficult to provide the kind of education we would like, but everyone feels that. So I do not feel it has a differential impact on women and minorities.

Ms. **Schneider**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Glickman?

Mr. **Glickman**. Dr. Saxon, on page 1 of your testimony you indicate that our capacity for scientific research and advanced scientific education is utterly dependent on continued assistance from the Federal Government. On page 4 of your testimony you say:

> I seem to see an Administration policy that makes demands on science and technology without making available the resources needed to meet those demands.

That implies to me the following: That the administration's policy is based on an attempt to stimulate productivity, to stimulate the economy by providing additional tax revenues and capital to do so. But it seems to imply that without the scientific side of the picture, perhaps new capital and plant will take us into old ideas or into nonproductive development, and therefore we are not getting anywhere. Is that perhaps what you are saying by that statement?

Dr. **Saxon**. I was picking up on Dr. Keyworth's statement and analysis in which he pointed out, I thought very persuasively, that our long-term productivity is critically dependent on our capacities in science and technology. The research is done in the universities, the education is done in the universities, and in order to produce those long-term gains, we need to have strong university programs in basic research. So there is an expectation and also a commitment to support it, but the commitment, it seemed to me, was somewhat fragmented, and that is what I was referring to.

Mr. **Glickman**. I guess my point is that the enhancement of capital is a necessary item to increase productivity, but that alone is not sufficient.

Dr. **Saxon**. I agree with that completely.

Mr. **Glickman**. OK. On page 8 of your testimony you give two excellent examples of what this funding reduction is doing. One is on the NASA issue, where you said you were asked to reduce the budget a couple of times and apparently the item was just totally zeroed out. For our benefit, since we have jurisdiction over the NASA budget, what was the nature of that program, if you know?

Dr. SAXON. I cannot give you any more than is in this document, but if you would like, I will get that to you.

Mr. GLICKMAN. Somebody is nodding behind you.

Dr. SAXON. Yes, we will get that.

[Material to be supplied follows:]

INFORMATION ON REDUCTIONS IN THE UNIVERSITY OF CALIFORNIA'S RESEARCH EFFORT SUPPLIED BY THE UNIVERSITY'S BERKELEY CAMPUS, JANUARY 1982

A typical example of the impact of funding uncertainties is one of our NASA projects (Isotopic Studies in Meteorites and Lunar Samples) due to expire on January 31, 1982. The project measured the rare gases in lunar samples and meteorites with and without prior neutron irradiation as a means of increasing our understanding of the origins and history of the Solar System. We had submitted a renewal proposal in the amount of $205,000. In November we were asked to reduce our budget to $170,000. In January, when we followed up on the status of the renewal, we were advised that funds had not yet been made available for the renewal. Our principal investigator had been advised by the program people at NASA Headquarters that they are making every effort to provide funds for the renewal including a no cost extension to keep the contract open. We have not been able to get a sufficiently firm commitment so that we will be able to allow the project to continue beyond January 31. Thus the investigator is forced to issue lay-off notices and take other steps preparatory to shutting down his project. Two graduate students, a half-time postdoctoral Reserach Physicist, an Assistant Specialist and a part-time secretary were to have been supported on this project.

Note.—The University recently received a four month no cost extension for this project, which means that, while the project is extended for four months, no Federal funds are available for its support; University funds must be used to maintain it. NASA is expected to resume funding on its own once its procurement request is approved and to reimburse the University, but in the meantime the University cannot use the funds for other purposes or earn interest on them.—Office of the President, March, 1982.

Mr. GLICKMAN. You also talked about the effects on the Lawrence Berkeley Laboratory. Apparently what you are saying is, not only the dollar amounts are concerning you but the uncertainty is driving you crazy.

Dr. SAXON. That is correct. Obviously, we are in a situation in which major changes are being made on a very large scale, and the full dimensions of those are not being spelled out in advance. That really mirrors the comment that Mr. Webb made about the impact on his industry.

We simply cannot respond very quickly to these changes. Even worse, the environment in which this kind of work is to be carried out deteriorates very dramatically, and that has an adverse impact on the quality of what is done, on students; it does make it extremely difficult.

Mr. GLICKMAN. OK. One final question, Mr. Webb. I have had an interest, as has the committee, in the use of natural gas as a motor fuel. I do not see anywhere in your materials any research being done by the Gas Research Institute in methane as an automobile or a transportation fuel. I wonder if it might have appeared in some subheading or if it is something that is an oversight. I wonder if you might comment on that?

Mr. WEBB. Yes, Mr. Glickman. The Gas Research Institute, working with AGA, has had some discussions with Ford Motor Co. As you know, Ford has recently announced they are coming out with a prototype vehicle in a couple of years that would use methane as fuel. The problem we are running into there is trying to identify truly the research that needs to be done and separating it from the marketing aspects of just getting the knowledge to the people that it is economical and it can be done today.

I think our research area will tend to focus on ways to increase the capacity of the car through better absorbance, so you can have a greater capacity of methane in the same size storage tank and looking at compressors. We probably will not get into the engine research, because there is no way we can duplicate what the motor companies themselves, such as Ford or GM can do.

Mr. GLICKMAN. But you are not ignoring the subject?

Mr. WEBB. No, we are not ignoring the subject. The reason it was not on this list is that it was not a cofunded program with DOE, and what I tried to show is where we are increasing to offset DOE's budget cuts.

Mr. GLICKMAN. Thank you very much.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Glickman.

Mr. Shamansky?

Mr. SHAMANSKY. Thank you, Mr. Chairman.

President Saxon, I am from Columbus, Ohio, which is the home of Ohio State University, Batelle Memorial Institute, and Chemical Abstracts, which are just along a very small river. I am very concerned, and I know the president of Ohio State, and Dean Glower of the College of Engineering are concerned about the ability of Ohio State to continue to turn out well trained graduates which industry needs, and having any students at all if the cuts contemplated by the administration go through. My question to you is, does the University of California, with all its many campuses, have a similar problem?

Dr. SAXON. Yes, we have that problem. I will not say ninefold; we have nine campuses, but each of them is not of the scale of Ohio State. But we have the problem manyfold. It is a problem which is of long standing.

As you try to estimate the impact, you ought to at least be aware of the fact that in the Department of Defense budget there is some funding, I believe, which is intended for equipment, not on the same scale as the NSF but at least some. So, there has been some recognition of that need.

Again, I would suggest that the problem here is not one of persuading people that the need exists. I think Mr. Keyworth knows it. I think his statement makes it clear. There have been a number of independent studies that make that clear. The National Science Foundation is aware. But the committees of Congress doubt it. So, it is again the problem of trying to strike balances. I would rate it as a very high priority need at my institution, just as it apparently is at Ohio State.

Mr. SHAMANSKY. In 1978, Dr. Saxon, I was in Peking in a private capacity, and we met with a graduate of Ohio State University who worked for the Chinese Academy of Sciences. She explained that during the Cultural Revolution they went to work but did nothing, so there was a hiatus of 10 years in which the Chinese scientific establishment did nothing.

It seems to me that we are experiencing almost a budgetary Cultural Revolution here which will have a long-range impact on the science and technology of this country. I think it is a continuum; you cannot stop it now and then, and say, pick up 5 years later, or whatever, and say you have not been hurt desperately by it.

Dr. **Saxon**. The long-term consequences in this area of actions taken today are one of the most important elements to be considered. I said earlier that I was not pessimistic, not because I think the problems are trivial, but because I think the level of understanding is great.

I would say that in China the seriousness of their problems was exceeded only by the lack of understanding of what to do about them. Totally disastrous decisions were made at the national level which served their long-term goals very badly.

I have every confidence in the capacity of this committee and its counterpart committees to deal with this in a reasonable way. I do not think we are facing a total disaster, but I think we are facing very serious problems, and I think the decisions made are going to have profound consequences for the long-term wellbeing of the country.

Mr. **Shamansky**. Dr. Saxon, with respect to this committee, I am happy to report that a truly bipartisan majority of this committee voted to eliminate $240 million—I think it was—for the Clinch River breeder reactor, which even David Stockman said was a turkey.

Unfortunately, at the same time that the administration cut back and wanted to cut back on science education and instrumentation, it put back that $240 million for purely political reasons in the sense that Mr. Baker is from Tennessee. That seems to me to be a problem which was taken out of the hands of this committee. How long can the scientific and technology establishment or part of our country sit silent on specific actions like that?

Dr. **Saxon**. As far as I can tell, Congressman Shamansky, there is little enthusiasm among my colleagues in the scientific community for the particular project you referred to, but I am barely expert in technology and science and not at all expert in politics.

Mr. **Shamansky**. Well, join the rest of us, Dr. Saxon.

Do the research universities have any way of coordinating your efforts? I have the feeling that you come up in a capacity representative of an association, but I am not sure that your group as such—whatever groups you are members of—go to their Congressmen of either Party and say what it is you want to do in this area and ask us to fight for it.

Dr. **Saxon**. I think that is a justified criticism. We do have our associations. For example, Ohio State University and the University of California belong jointly to at least three that I know: the American Association of Universities, which tends to focus on research interests; the Land Grant Association, which has a somewhat broader set of constituents; the American Council on Education, which has every higher educational institution in its constituency. All of those associations are engaged, in one way or another, in trying to develop general views.

On the other hand, it is, I think, an intrinsic aspect of American life that our universities, unlike European ones, are really quite individual, independent entities. Thus, Ohio State University, after all, is a university which functions in Ohio, largely for the people of Ohio, although it has a national purpose as well. The University of California functions in a different environment. If we were in Europe, we would all be under some ministry of education and it would be very easy to get the kind of coherence you talk about.

It is one of the strengths of our system that we have this diversity, and I think it is something we ought to nurture. But it means that you have to be as understanding as you can about the fact that you will sometimes get advice which lacks total coherence. Sometimes you are going to have to do the integrating instead of having it done for you. But that is not all bad. The fact that it is presented in such a way gives you an opportunity to see for yourself the true diversity of views, as well as of institutions, in this country on issues that are very important.

Mr. **Shamansky**. Thank you, Dr. Saxon.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Shamansky.

Mr. Dymally?

Mr. **Dymally**. Mr. Henriques, given the fact that the Japanese Government has just advanced the computer industry several billion dollars in a cooperative effort to catch up with your industry, do you believe your industry can survive without Federal research funds with this threat facing us?

Mr. **Henriques**. Yes, I think it can without direct support to the industry from the Government.

Mr. **Dymally**. Not direct support, research support.

Mr. **Henriques**. That is what I am saying—direct research support. I think the direct research support is more appropriate into the academic community.

The need for engineers and scientists is perhaps more critical to our industry than the direct subsidization of research and development within the industry. To achieve this, we need to support very strongly the universities and centers that have microelectronic research going on, programming research going on, and mathematical theory research going on.

I might make the comment, however, that our industry feels that we should have a relationship to Federal R. & D. policy but that we do not want to follow the Japanese model. We see no need for a MITI-type organization and the direction of research and the direction of product development being done by the Government.

Mr. **Dymally**. Even though they may catch up with us and beat us?

Mr. **Henriques**. It is not really apparent that they will catch up with us.

One of the things that we do need is a less adversarial relationship with the Government in terms of tax structure, information policy, and the problems of joint R. & D., as I mentioned. In Japan, research that is developed by one university or one company is shared by all. If we tried that in this country, we would all be visited by the Justice Department and probably locked up. I think it is that difference in philosophy which is more threatening to us than the fact that they poured so many dollars into the research effort.

Mr. **Dymally**. Mr. Webb, if Federal funds were withdrawn for research and your industry had to resume that responsibility, would you move into alternative sources also?

Mr. **Webb**. By alternative sources, you mean other than gas-related?

Mr. **Dymally**. Yes.

Mr. **Webb**. Under our current application to the Federal Energy Regulatory Commission, we could not, for the simple reason that we can do research on new types of gas supply. We can certainly do research on biomass, because biomass is a product that can be converted to a gas. We can do research on anything that can be converted to a gaseous fuel, or we can do research on more efficient ways to use gas. But we would be precluded, since the money is actually funded from the gas users in this Nation, from doing research, let us say, on solar that had no possible interface with the gas system.

Mr. **Dymally**. Dr. Saxon, we face, obviously, a crisis in the classroom, from elementary all the way through the university system. But, it seems to me that we also face a crisis in communicating that message to the administration. You have a very active member of your board of regents in this administration. As a California resident, he was one of the university's big supporters. Are you communicating that message to him, so that he can communicate it to the administration now?

Dr. **Saxon**. I communicate that message to anybody that will listen to me, and I do it all the time.

Mr. **Dymally**. But, do you have a chance to communicate with him, now that he is a District of Columbia resident?

Dr. **Saxon**. Well, I have to worry a little bit about conflicts of interest in that regard.

Mr. **Dymally**. But he is a member of the board, and therefore it seems to me that that message ought to be conveyed to the administration.

Dr. **Saxon**. That is the point. We keep our board informed of these issues. They are very important to the board of regents. We report to them on it and report to them on programs that we are initiating, and every member of the board receives that information. But I could not single out a member of the administration who happened to be a member of the board for some kind of special attention. I think that would be grossly inappropriate and unfair to him as well.

Mr. **Dymally**. You would not have any hesitation to communicate with him as you do with the speaker of the California assembly, who was a member of your board and passed on your budget.

Dr. **Saxon**. Yes, I do that all the time.

Mr. **Dymally**. I mean you do that all the time. You communicate with the speaker, who is a member, and you see no conflict there.

Dr. **Saxon**. I only communicate with the speaker either as a member of the board of regents or in connection with our presentations to the legislature, if we are presenting something, just as here.

Mr. **Dymally**. Has there been any special message to the board about this crisis we face in the classroom?

Dr. **Saxon**. Yes.

Mr. DYMALLY. Could I get a copy of that message, so I could send it to my ex-fellow board member?

Dr. SAXON. Yes.

Mr. DYMALLY. Thank you very much.

[President Saxon's February 19, 1982, statement to the Regents on the effects of the Federal budget on the University of California follows:]

PRESIDENT SAXON'S STATEMENT ON THE EFFECTS OF THE FEDERAL BUDGET ON THE UNIVERSITY OF CALIFORNIA

DAVID S. SAXON, PRESIDENT
UNIVERSITY OF CALIFORNIA — FEBRUARY REGENTS' MEETING — SAN FRANCISCO
FEBRUARY 19, 1982

THE FEDERAL GOVERNMENT IS IN THE MIDST OF A FUNDAMENTAL RE-EXAMINATION OF ITS PROPER ROLE IN THE LIFE OF THE NATION AND OF THE CHANGES THAT SHOULD BE MADE IN THE WAY THE GOVERNMENT DOES BUSINESS. I WANT TO TALK TO YOU TODAY ABOUT OUR PRESENT ASSESSMENT OF THOSE MAJOR CHANGES IN FEDERAL PROGRAMS AND SPENDING THAT HAVE CORRESPONDINGLY MAJOR EFFECTS ON THE UNIVERSITY. IN ORDER OF THE DIFFICULTY AND URGENCY OF THE PROBLEMS THEY PRESENT, I WILL DISCUSS FIRST, STUDENT FINANCIAL AID; THEN MEDICARE AND MEDI-CAL SUPPORT OF PATIENT CARE; NEXT, RESEARCH SUPPORT; AND LAST, THE DEPARTMENT OF ENERGY LABORATORIES.

WE ARE ALL WELL AWARE OF PRESIDENT REAGAN'S EFFORTS TO CONTROL THE GROWTH OF FEDERAL EXPENDITURES AND INDEBTEDNESS, EFFORTS WHICH ARE INTENDED TO FREE RESOURCES TO STIMULATE THE ECONOMY'S PRODUCTIVITY AND HEALTH. WE ARE NOW IN A PERIOD OF LARGE REDUCTION IN FEDERAL PROGRAM BUDGETS--A PERIOD THAT IS EXPECTED TO CONTINUE FOR A WHILE YET. AT LEAST IN THE SHORT RUN, THE ECONOMY IS IN RECESSION, A SITUATION WHICH MAKES THE PRESIDENT'S TASK EVEN MORE DIFFICULT AS REVENUES ARE REDUCED AND MONEY REMAINS EXPENSIVE. NEVERTHELESS, THE ADMINISTRATION IS OPERATING ON THE EXPECTATION THAT ITS EFFORTS WILL BE SUCCESSFUL, AND THAT A LONG-RUN SURGE IN PRODUCTION WILL BEGIN. HOWEVER, TO ACHIEVE THE PRESIDENT'S GOAL, A VIGOROUS NATIONAL EFFORT IN SCIENCE IS ESSENTIAL TO PROVIDE THE RESEARCH NEEDED TO PROMOTE PRODUCTIVITY AND, EQUALLY IMPORTANT, A HEALTHY educational system is indispensable to provide the educated men and women on whom that research, and its innovative application, depend.

George Keyworth, the President's Science Advisor, has explicitly stated that the Administration is committed to support basic science and, further, that the support of scientific and academic research to sustain our national capacity and to overcome serious obsolescence in equipment and facilities is an important investment in the future. At the same time, however, the Administration is clearly and deliberately set on reducing Federal support of higher education in the form of student assistance and other science education programs. These two courses of action seem to me fundamentally inconsistent. It does not make sense to acknowledge the important role science plays in our national well-being while at the same time reducing support that enables students to attend college, and particularly to continue their studies as graduate students. It does not make sense to diminish resources available for improvement of scientific education throughout the school system.

Thus, from my perspective there seem to be mixed signs and portents in Administration policies affecting science, technology, and education. These mixed signs are a source of tremendous uncertainty, doubt, and anxiety about the direction of our national effort in science and education, not only for those agencies administering Federal programs, but also for the community of faculty, students, and staff of universities in general and the University of California in particular. This uncertainty is compounded by the very complicated and confusing nature of the Federal budgetary process, which has yet to settle the 1982 budget while beginning the Congressional process for 1983.

Let me now turn to the four major areas of concern.

1. Student Financial Aid

In 1980-81, which we shall take as our base year for this discussion, the University received about $130 million in Federal student aid: about $20 million in certain campus-based programs, another $20 million in need-based grants (called Pell Grants), and $90 million in Guaranteed Student Loans (GSL). By 1984, changes already adopted or proposed for these programs would decrease this sum by more than 75% from $130 million to $30 million, a decline which can fairly be described as catastrophic. Let me take these three program categories in order.

- Campus-based programs. There are three Federal programs administered by the campuses--Supplemental Educational Opportunity Grants (SEOG), National Direct Student Loans (NDSL), and College Work-Study (CWS). All of these programs are need-based and serve the less affluent of our students. The allocations for these programs for 1982-83 have already been cut from the 80-81 base by 27% in NDSL, 15% in SEOG and 3% in CWS. What this means is that the University of California will find it much more difficult to maintain past levels of support to students with financial need, much less make increases for inflation. Nonetheless, we will make every effort to protect students whose need is most urgent. Let me add that students have not yet felt the effects of these cuts in the current academic year because these programs are forward funded--that is, the FY 82 appropriations apply to the 82-83 academic year.

Unfortunately, prospects for FY 1983 are much worse. That budget proposes to eliminate the SEOG and NDSL completely and to cut Work-Study by 30%.

•Pell Grants. Our students have already been affected by cutbacks in the Pell Grant program. Reduction in the past two years has been $130 per award, even though college costs have escalated. We estimate that this reduction has kept over 2,000 recipients at the University from receiving Pell Grant help to continue their education. If the changes proposed in the FY 1983 budget are adopted, the funds available will be cut by about half in 1984 compared with 1981.

•Guaranteed Student Loan. The full impact of the change in eligibility for the last of these financial aid programs--Guaranteed Student Loan--also has not yet been felt by our students. That impact will be known once applications are made for 1982-83. Furthermore, graduate students will no longer be eligible for such awards, regardless of need, effective this year. They will instead become eligible for an Auxiliary Loan program that is much more costly to the student and that has yet to be accepted by the banks. The cost of the loans has already increased because of a 5% loan fee. It is proposed to double that fee to 10%.

The impact of these changes on all of our graduate and professional students will be severe, for at present there are 9,000 such students at the University now receiving GSL who would no longer be eligible.

Cumulatively, these cuts would represent, as I mentioned earlier, a loss of 75% of the dollars for student financial aid by 1984, and this at a time when college costs are rising. We are still not certain of the precise effects of all of this on University of California students, except that it will reduce or eliminate thousands of awards and fellowships, not only for middle income students but for low income and minority students as well.

2. Medicare - Medi-Cal

We estimate that in 1980-81 our hospitals received about $184 million in reimbursements from Medicare and the Federal portion of Medi-Cal (Medicaid). In addition, physicians' fees paid through these programs are a source of support for our compensation plans. Presumably, these reimbursements will diminish as Medicare and Medi-Cal are cut back. Major changes have been instituted in both Medicare and Medi-Cal that will widen the gap further between costs and reimbursements: The University's 1980-81 shortfall of $50 million is expected to increase by $19 million to $69 million in 1981-82.

For the University, Federal budget cuts requiring a retrenchment of the Medicare and Medi-Cal programs have serious cumulative implications. These programs finance the care of more than one-half of the patients in the University's teaching hospitals. They provide about half of the hospitals' revenues, as well as substantial additional revenue from physicians' fees, revenue that flows into our compensation plans, as I have already said. Further, Federal cuts are often translated into State cuts, because health care funding of the massive Medi-Cal program is a joint responsibility.

Unfortunately, the $19 million shortfall in 1981-82 that I mentioned earlier is merely the first storm warning. The reasons are at least two: first, without knowing the details of the FY 1983 budget--no one could at this point--the Governor has anticipated the prospects for the State created by a revenue shortfall, compounded by current Federal cuts. As a result, he has included in his 1982-83 State budget certain far-reaching Medi-Cal cuts, including a freeze on cost-and-charge increases for the next fiscal year. Second, President Reagan's 1983 budget includes cuts for Medicare and Medicaid that will dwarf the FY 1982 shortfalls. According to the State Controller's Office, these cuts may cost California as much as $500 million.

3. Research

During 1980-81 the campuses were awarded $519 million in Federal contracts and grants, 12.5% of all Federal dollars awarded to colleges and universities. We estimate that this will decline by $26 million in 1981-82. The consequences of the reduction are difficult to analyze, and all the more so because it is an aggregate of the net of various cuts and increases. One pattern is clear, however. As Attachment 1 indicates, there is a general loss of support from civilian agencies except agriculture, but large increases in funding from the Department of Defense. However, those agencies slated to receive increases are the source of only a small fraction of our total support. And the award totals do not reveal what may be a very real shift in the nature of programs the Federal government is willing to sponsor. Reduced research funding for projects in the social sciences and humanities makes it clear that they are targets of a shift of emphasis. Other program changes are apparent in energy research. If changes in Federal spending patterns continue, the ability of the University to conduct research in some disciplines will be substantially affected. Some particulars of how reductions in Federal research money have influenced the research of principal investigators on the campuses are shown in Attachment 2, "Examples of Some Campus-Reported Reductions in the University of California's Research Effort."

Turning now to 1982-83, I can report that the situation promises to be rather better. The FY 83 budget proposal calls for an 8.3% increase in basic research supported by the major Federal departments and agencies. This 8.8% will keep up with inflation and perhaps a little more. This increase, it should be noted, is not inconsistent with the Science Advisor's announced policy of Federal support for research of the kind largely conducted by the nation's colleges and universities. If we continue to compete vigorously for Federal funds, the University of California will, I have no doubt, get its share of these program funds.

4. The Department of Energy Laboratories

The University's relationship with the DOE Laboratories is quite different from that with our hospitals and with our other campus-based teaching and research programs. Nonetheless, our management responsibility is affected by substantial changes resulting from the new policy and funding patterns of the Department of Energy.

The Lawrence Berkeley Laboratory experienced a budgetary loss of 10.4%, before inflation, and reports the loss of 435 career and contract personnel, over 10% of the total staff. Programmatic reductions or eliminations have been made in geothermal, combustion, fossil, oil shale, and biomass research projects. LBL's High Energy Physics project is facing reorganization and reduction of staff.

At the Los Alamos National Laboratory, a budget increase of 9% is projected, but this figure is 16% less than escalated costs demand, and Los Alamos is facing a $30 million revenue shortfall. Voluntary staff reductions were sought, and 259 employees volunteered for separation. Another 100 involuntary separations may be needed. The programs most seriously affected by the revenue shortfall are Fossil Energy, Conservation, Energy Research, and the Nuclear Energy programs.

The Lawrence Livermore National Laboratory received a 9% budget increase, but this is less than the 10.2% cost escalation at the Laboratory. The 1982 Federal budget required a reduction of 300 staff FTE, but the Laboratory believes this figure can be reached through normal turnover. The Laboratory reports its weapons research and special Isotope Separation funding are up significantly, while the Inertial Confinement Fusion funding was reduced by 10% and the Energy Conservation and Health and Environmental Research programs were reduced.

The Laboratory of Nuclear Medicine and Radiation Biology at Los Angeles finds its budget 7.7% lower for the year, not taking into account the effects of inflation. Four of twenty staff have left the Laboratory, and the Exchange Program in Biomolecular and Cellular Sciences was dropped, while the Environmental Biology Program received only half of its usual support.

Conclusion

As these budget reductions are registered throughout the University of California system, another immediate and perhaps equally serious problem may be developing. The uncertainty created by the Federal budget has apparently affected the pattern of submission of proposals by faculty. The Systemwide Office of Contracts and Grants reports (see Attachment 3) that new proposals for Federal awards are about 20% less in the first half of this academic year than at the same time in 1980-81. Moreover, fewer proposals were made in the second quarter (October-December) of this fiscal year than in the first quarter, suggesting that principal investigators may be considerably less certain of what Federal agencies can or will fund. Unless this trend reverses itself (and it may), the University will obtain fewer Federal dollars in FY 1982-83 than it ought.

Together with the Chancellors and other administrators as well as many on the faculty, I am working to address the issues raised by the Administration's policy changes. I recently testified before the House Science and Technology Committee on the general topic of "Science and Technology under Budget Stress." A copy of that testimony is included with this report as Attachment 4. Closer to home, we are making a deliberate effort to bring information to students and their parents about proposed changes in financial aid. We are working with groups of faculty and government agencies on various elements of the research support budget. We are

ENGAGED NATIONALLY AND IN CALIFORNIA IN DISCUSSIONS ON THE FUTURE COURSE OF SUPPORT FOR HEALTH CARE, PARTICULARLY IN TEACHING HOSPITALS.

IN SUMMARY, RECENT CHANGES IN PATTERNS OF FEDERAL FUNDING HAVE SO FAR HAD THE FOLLOWING CONSEQUENCES:

1. WE EXPECT A DECREASE IN SUPPORT FOR STUDENT FINANCIAL AID OF $2.3 MILLION IN GRANTS, AND $60 MILLION IN LOANS, BY THE NEXT ACADEMIC YEAR. WE ARE FACING PROPOSALS FOR EVEN MORE MASSIVE REDUCTIONS IN THE FOLLOWING YEAR.

2. WE ESTIMATE HOSPITAL REIMBURSEMENTS FOR MEDICARE-MEDI-CAL FOR 1981-82 WILL BE AN ADDITIONAL $19 MILLION SHORT OF COSTS. THE PROSPECTS FOR 82-83 AND BEYOND CAN ONLY BE DESCRIBED AS FRIGHTENING.

3. WE ESTIMATE A DECREASE IN RESEARCH SUPPORT OF PERHAPS AS MUCH AS $26 MILLION THIS YEAR. NEXT YEAR, HOWEVER, WE ANTICIPATE A TURN-AROUND, COUPLED TO SOME AS YET UNKNOWN CHANGES IN DISCIPLINARY EMPHASIS.

4. THE LABORATORIES HAVE BEEN REQUIRED TO REDUCE THEIR WORK FORCE BY AT LEAST 1,000 PERSONS, AND BUDGETARY CUTS HAVE FORCED THEM TO SHIFT SOME PROGRAM EMPHASES.

WHAT I HAVE PRESENTED TODAY HAS LARGELY BEEN A RECITAL OF FACTS, ALTHOUGH SOME EDITORIAL COMMENT HAS CERTAINLY CREPT IN. BUT IN THAT RECITAL SOMETHING IMPORTANT IS MISSING. I HAVE NOT CONVEYED, AND PERHAPS THERE IS NO WAY I CAN CONVEY, THE IMPACT OF ALL OF THIS ON OUR STUDENTS, FACULTY, AND STAFF. THE MAJOR TRANSFORMATIONS IN FEDERAL POLICY NOW BEING FORMULATED AND IMPLEMENTED IN WASHINGTON ARE ACCOMPANIED--INEVITABLY--

BY UNCERTAINTY AND CONFUSION. DESPITE THE BEST EFFORTS OF FEDERAL OFFICIALS, THAT UNCERTAINTY AND CONFUSION ARE TRANSMITTED TO US, WITH UNINTENDED DISTORTION AND EVEN AMPLIFICATION. THIS MEANS THAT IT IS EXTRAORDINARILY DIFFICULT FOR US TO PLAN OUR RESEARCH PROGRAMS, WHICH SIMPLY CANNOT RESPOND TO SHORT TERM CHANGES; TO CARRY OUT OUR HEALTH CARE RESPONSIBILITIES; AND, MOST OF ALL, TO PROVIDE GUIDANCE FOR OUR STUDENTS, WHO MUST BEAR AN INTOLERABLE BURDEN OF UNCERTAINTY AS THEY TRY TO PLAN FOR THE FUTURE. AND NOT ONLY OUR STUDENTS. STUDENTS IN THE HIGH SCHOOLS MUST DECIDE ON A TIMELY BASIS, WHETHER THE FEDERAL BUDGET IS READY OR NOT, ABOUT WHERE--AND IF--THEY ARE GOING TO CARRY THEIR EDUCATION FURTHER. SIMILARLY, STUDENTS AT THE UNDERGRADUATE LEVEL IN COLLEGES AND UNIVERSITIES THROUGHOUT THE NATION MUST DECIDE WHETHER AND WHERE TO PURSUE THEIR EDUCATION AT THE GRADUATE LEVEL. LET ME ASSURE YOU THAT THESE BURDENS ARE REAL AND THAT THEIR CONSEQUENCES, IF NOT YET KNOWN, ARE CERTAIN TO BE LARGE.

AS DEVELOPMENTS TAKE PLACE, I WILL CONTINUE TO KEEP YOU INFORMED.

TABLE 1 Attachment 1

ESTIMATED PROJECTIONS FOR FY 82 FEDERAL RESEARCH SUPPORT FOR THE UNIVERSITY OF CALIFORNIA ADJUSTED FOR THE DECEMBER CONTINUING RESOLUTION OF A 4% REDUCTION IN DOMESTIC SPENDING (IN MILLIONS)

	UC FY 80-81 Awards	Projected UC FY 81-82 Awards 1/ 2/
ADAMHA*	$ 39.4	$ 35.9
NSF	97.7	91.4
ED/NIE	21.1	19.5
COMM./NOAA	5.8	3.6
INTERIOR/WATER	.9	0
AGRICULTURE	6.9	7.6
NASA	19.2	16.5
DOD	49.0	60.2
NIH**	214.3	202.1
NEA/NEH	3.8	2.9
DOE	25.9	21.9
EPA	5.6	5.0
LABOR/CETA	3.3	0
STATE/AID	.3	1.5
OTHER***	25.9	24.9
TOTAL	$519.1	$493.0 ($452.7 in 1980-81 dollars.) 3/

*Alcohol, Drug Abuse, Mental Health Admin.

**Includes:

$ - 5.6m. PHS/Training & Institutional Grants

+ 1.8m PHS/NIH Research Awards

$ - 3.8m.

***Includes Dept. Justice, Dept. Transportation, Veterans Admin., et al.

1/ To prevent distortion, multi-year losses or gains are shown here on an annualized basis.

2/ Projected UC FY 82 awards is estimated by subtracting campus reported funding changes and the December Continuing Resolution 4% loss from UC FY 80-81 awards.

3/ Inflation adjustment is based on formula used by the Office of the Legislative Analyst, State of California. Projected inflation is 8.9%.

Attachment 2

TABLE 2

SUMMARY OF UNIVERSITY OF CALIFORNIA FEDERAL CONTRACT AND GRANT PROPOSALS

	7/1-9/30/80	#of Proposals	7/1-9/30/81	#of Proposals	%Δ in # of Proposal
Berkeley	$ 36,855,815	317	$ 42,689,129	200	-36.9
San Francisco	47,743,680	327	42,056,824	171	-47.7
Davis	20,419,990	114	42,121,846	237	+107.9
Los Angeles	54,544,259	290	72,907,806	239	-17.5
Riverside	5,426,941	47	13,003,080	51	+ 8.5
San Diego	57,215,455	260	96,616,748	260	0
Santa Cruz	6,918,410	47	2,404,261	27	-42.5
Santa Barbara	13,425,555	78	9,571,016	67	-14.1
Irvine	19,328,654	108	21,064,318	92	-14.8
	$261,853,759	1,588	$342,435,028	1,344	-15.4 %Δ # +30.8 Δ $

	10/1-12/31/80	#of Proposals	10/1-12/31/81	#of Proposals	%Δ in # of Proposal
Berkeley	$ 56,152,731	333	$ 60,634,657	287	-13.8
San Francisco	52,963,419	363	28,208,783	225	-38.0
Davis	45,906,914	203	24,151,596	126	-37.9
Los Angeles	144,772,053	485	108,098,140	434	-10.5
Riverside	6,875,085	68	8,514,021	51	-25.0
San Diego	95,532,421	400	87,153,953	227	-43.2
Santa Cruz	19,606,155	123	17,663,283	129	+ 4.9
Santa Barbara	5,138,417	62	3,181,686	34	-45.2
Irvine	25,490,323	154	33,913,202	134	-13.0
	$452,435,518	2,191	$371,519,321	1,647	-24.8 %Δ # -17.9% Δ $

TABLE 2 Page 2

1st & 2nd QUARTER TOTALS

	7/1-12/31/80	#of Proposals	7/1-12/31/81	#of Proposals	%Δ in # of Proposa
Berkeley	$ 92,988,546	650	$103,323,786	487	-25.1
San Francisco	100,707,099	690	70,265,607	396	-42.6
Davis	66,326,904	317	66,273,442	363	+14.5
Los Angeles	199,316,312	775	181,005,946	673	-13.2
Riverside	12,300,026	115	21,517,101	102	-11.3
San Diego	152,747,876	660	183,770,701	487	-26.2
Santa Cruz	26,524,565	170	20,067,544	156	- 8.2
Santa Barbara	18,563,972	140	12,752 702	101	-27.9
Irvine	44,818,977	262	54,977,520	226	-13.4
	$ 714,294,277	3,779	$713,954,349	2,991	-20.8% Δ # - .00048% Δ $

Attachment II

EXAMPLES OF SOME CAMPUS REPORTED REDUCTIONS IN THE UNIVERSITY OF CALIFORNIA'S RESEARCH EFFORT

Berkeley: "A typical example of the impact of funding uncertainties is one of our NASA projects (Isotopic Studies in Meterorites and Lunar Samples) due to expire on January 31, 1982." The project measured the rare gases in lunar samples and meteorites with and without prior neutron irradiation as a means of increasing our understanding of the origins and history of the Solar System. "We had submitted a renewal proposal in the amount of $205,000. In November we were asked to reduce our budget to $170,000. In January, when we followed up on the status of the renewal, we were advised that funds had not yet been made available for the renewal. Our principal investigator had been advised by the program people at NASA Headquarters that they are making every effort to provide funds for the renewal including issuing a no cost extension to keep the contract open. We have not been able to get a sufficiently firm commitment so that we will be able to allow the project to continue beyond January 31. Thus the investigator is forced to issue lay-off notices and take other steps preparatory to shutting down his project. Two graduate students, a half-time postdoctoral Research Physicist, an Assistant Specialist and a part-time secretary were to have been supported on this project."

"Sizable reductions (from the National Endowments for the Arts) are being experienced in awards to the University Art Museum. We now project a loss of the order of magnitude of $40-50,000," as NEA reduced 10% from the seven proposals for $500,000 which eventually were funded.

San Diego: NASA deferred the Gamma Ray Observatory project at San Diego. The project studied Gamma Rays emitted from celestial objects like super novas, solar flares, black holes, neutron stars, etc. The radiation "signatures" found in Gamma Rays, which were to be picked up by the Observatory project, identify what elements exist in these objects. The project called for $20.5 million in funding, and was scheduled to last from 1979 through 1986. One million dollars of the total has been spent up to this point, and an estimated $1 million would be spent in FY 1982. The long-term loss to the University is $19.5 million. Of the total award, $8 million was to be spent directly on the campus with the rest of the project to be subcontracted to businesses throughout California and the San Diego area. The project's deferral ended an international study conducted by 20 principal investigators from 6 institutions. According to the lead principal investigator, Dr. Lawrence Peterson of UCSD, relations with fellow researchers in France were strained by the cancellation. Dr. Peterson says the project was to have been the primary research activity of San Diego's Center for Aeronautics Space Science for the entire 1980 decade, and was the next step of his 15 to 20 years of research. The Center could lose 3 to 7 technical staff.

The campus lost $615,200 in CETA money from the Department of Labor which "has significantly reduced resources for general administration and facilities maintenance." While 69 CETA personnel were let go from San Diego, the UC System altogether lost 295 persons and a loss of $3.3 million from 1980-81. Resources which could have been used to support research projects are now needed to cover the maintenance and administrative effort once provided by CETA workers.

Santa Barbara: The "Water-Pollution-Great Lakes" project funded by the Environmental Protection Agency previously approved for three years beginning in 1981, "at 100K per year got partial support for one year. No new hires; would have meant two students and a postdoctorate.

Riverside: Loss of $500,000 from the Department of Energy means the Riverside "Geothermal Research program will be severely limited." Though the campus is seeking alternative funding, the resources for supporting three student assistants is lost.

San Francisco: "One very unhappy example of the results of cuts in federal funding is at Langley Porter Psychiatric Institute. It is the abrupt ending of a contract from the National Institute of Child Health and Development to study the causes of dyslexia—a form of reading disability—in children. Initial results suggested significant advances in the scientific understanding of this disorder. Three years worth of painstakingly collected data characterizing dyslexia children in terms of brain electrical activity and other factors now cannot be analyzed and reported. Most members of the research team (13 out of 15 people), including an internationally renowned investigator (Dr. Charles Yingling), will have to find positions elsewhere."

Davis: The Laboratory for Energy Related Health Research at Davis has experienced a 20% reduction in its $3.9 million set of awards in 1981. The Laboratory's mission to study the long-term biological and health effects of energy derived pollutants. The budget cuts sustained this year forced the lay-off of 23 people, including the Laboratory's staff biochemist and organic chemist. The Laboratory no longer has in-house capability for biochemical analysis and only limited organic chemical analysis.

The Laboratory receives its primary funding from three agencies. Its Department of Energy awards are $2.86 million this year, down from $3.26 million in 1981. A "coal-oil mixtures" project of $340,000 was eliminated, which would have identified coal-oil mixtures and the effects of burning such mixtures on tissue cultures.

One Environmental Protection Agency award of $248,000 was cut, thus terminating a "coal-fly-ash" study, which investigated the long-term effects of inhaling coal-ash compounds.

Funding for the Nuclear Regulatory Commission fell to $255,000 this year from $283,000 in 1981. One project eliminated due to this reduction was to have confirmed the adequacy of present NRC standards that set limits on the legal exposure to low-level radioactive substances.

The Laboratory reports all studies have a reduced efficiency in their research efforts.

Mr. **Fuqua**. Thank you, Mr. Dymally.

Ms. Heckler?

Ms. **Heckler**. I feel personally that one of the real problems in engineering education, judging by my Massachusetts experience, was the boom and bust cycle of Federal funding in aerospace and in Government contracts in general. I well remember the period when the Government decided not to invest and engineers or Ph. D.'s who were 49 or 50 and who were on the verge of suicide; a certain number did commit suicide over the loss of job opportunity, the loss of a career, and their inability to translate their engineering background into skills that were saleable in the marketplace.

I think today there is a lot of hesitancy among young students to take on an engineering career because the memory is still fresh, at least in our area, of what happened when the Government changed its course and when engineering was no longer required. I think that is one of the reasons that we do not have the interest in engineering.

How do we avoid this if we develop the personnel that I think is truly needed by industry in the field of engineering? How do we reassure them that the boom and bust cycle is not going to return, that their future is going to be a stable and productive one?

Dr. **Saxon**. I referred earlier to the roots of the present shortage of engineers and the same phenomenon you talked about. In a free society it is quite impossible to give absolute assurances of this sort. I do think, however, that in a free society we ought to be free to learn from our experience.

One of the lessons that I draw from those earlier events is that, whatever else we are good at in this country, manpower prediction is not one of them. As a matter of fact, as far as I can tell, even in societies where Government planning is total, manpower predictions are something that is done very, very badly indeed. So I think we ought to be very cautious about overreacting when these kinds of events occur.

Typically, we see signs of change occurring in our estimates of manpower needs. By Government participation we actually worsen rather than moderate such changes. In other words, a little recognition of the fact that these cycles are inevitable but that they work their way slowly would help a great deal. The catastrophic event is one in which we do not have people we desperately need.

With respect to engineers, statistically at least, the impact of those events of a decade ago was really relatively small compared, let us say, to what is happening to people working in the automobile industry today, a major problem in which a very, very substantial number of people are not going to have jobs and are going to find it very difficult to find other jobs.

Engineers are generally well educated people with long-term commitments. The number involved a decade ago was really quite small, if you looked at it carefully, and most of them were eventually able to find other work. But it is very difficult for an individual, of course, and there is no way we can guarantee that any individual is going to be immune from those kinds of problems.

Ms. **Heckler**. I would agree with that. I do not believe there is a no-risk lifestyle or career.

I just wonder about the diversification of contract sources in the private sector. Certainly, if industry did not totally rely on Government contracts but developed foreign markets and private contracts, and diversified its customer list, then you would not have a boom and bust cycle for engineers related to Government shifts in priorities. Is that happening in the high technology field, would you say?

Dr. **SAXON**. Again, I think that wherever you have a single sponsor for an activity, there is some danger. Right now, the defense-related industries are building very dramatically. Clearly, the only customer for defense activities is the Federal Government.

It seems to me that one needs to understand very clearly what the implications of this build-up are, what its long-term consequences are, and how to deal with both. That is a governmental matter; it is nothing that any of us can control. If you look, on the other hand, at an industry such as computer science, while the Government is clearly a major buyer, it is not the only buyer, and there is protection in that.

Biotechnology, which is a newly developing field, is one in which I do not see large Federal Government involvement. In fact, it would make me nervous if the Federal Government became the principal sponsor or buyer of those products.

Ms. **HECKLER**. Thank you, Dr. Saxon.

Thank you, Mr. Chairman.

Mr. **FUQUA**. Thank you very much, Ms. Heckler.

I want to thank all of our witnesses this morning for very excellent testimony and the answers to questions. I think you can see that there is a great deal of interest in the subject that we are all very concerned about. Thank you all very much.

Mr. **FUQUA**. Our next witness this morning is our colleague, Berkley Bedell, from Iowa.

Berk, we are happy to have you back testifying again this week. I apologize for the delay, but I think, as you can see, there is a great deal of interest in this subject matter.

STATEMENT OF THE HONORABLE BERKLEY BEDELL, A MEMBER OF THE HOUSE OF REPRESENTATIVES FROM THE STATE OF IOWA

Mr. **BEDELL**. I certainly can, Mr. Chairman.

I know the hour is late. I do not have prepared testimony, but I was most anxious to come over and speak to the committee, because of some of the strong beliefs and concerns I have in this particular area.

Current policies are based upon supply side economics. As I understand it, the proposal is that if we increase our productivity and produce more goods, our economy will take off. I think that philosophy makes some sense, but I believe it starts in the middle, Mr. Chairman, we are not really looking at what it is we are going to do.

I think the question is, what are we going to produce? Are we going to produce more TV sets when we already have several in each home? Are we going to produce more commercial airlines similar to those that are now in storage at all the various different airlines? Are we going to produce more cars that are similar to the ones we already have, or are we going to go forward with new technology and with new items that will change the way we live?

I thought Mr. Glickman's question was right on the button. If we are really going to move forward into new products, into a new world, and give new tax breaks so we can go ahead and make more of the old products we already have, clearly, in my opinion, it is not going to work.

I am very sorry that Mr. Shamansky has left. I would urge everybody to read the article that he had in the New York Times just in the last 2 or 3 days in regard to automobiles. I thought it hit right square on the head.

We are in tough times. As Mr. Lujan mentioned, we are cutting back. I come out of a business background, Mr. Chairman, and I agree with Mr. Saxon; we had better look at the long term. When businesses find themselves in difficulty, they can cut back, if they wish to, on their research, on their promotion, and on their advertising, because they do not have the money, and the result is absolutely assured. That business is going to die.

On the contrary, when they get in trouble, they can say, "We are going to go forward, and we are going to increase our effort in research, develop new products, we are going to advertise those new products, and we are going to go forward." Those companies will prosper when times are good or bad.

Whether or not we like it, we compete today in international markets. I happen to believe we are just on the knife-edge of a whole new world of new technology. I believe a lot of this came out of the space program.

It is unusual for a Member of Congress to ever admit he has been wrong, but I have to tell you, I have been wrong. I did not properly support the space program. I could not see us spending all that money going to the Moon when we had all these problems down here. Of all the things that have come from that space program, I now know it was one of the greater things that we have done in our society.

When people tell you that Government is inefficient, they are going to do things wrong, and all that, they are right, but the fact is that Government took us to the Moon, and I think it shows what we can do if we work together.

Whether we like it or not, the Japanese and the Germans are going to go forward. They are working together in order to go forward. There is certainly room for disagreement, and I have to tell you I disagree with the gentleman who just testified that he thought the Japanese are not going forward ahead of us, not passing us. I think they are making fools out of us, frankly. I think if he had been testifying for binoculars, cameras, TV's, or automobiles, he might have had a little different concern. My concern is not just what they have done; my concern is what it is that they are going to do.

So I am afraid we will sit back and let them pass us by. I think they are going to pass us by in the world markets for new products. I think they are going to pass us by in regard to our standard of living if we sit here. I think they are going to pass us by in economic development if we stick to the old.

I urge this committee to recognize the importance of moving forward with new technology that can make this world a better place in which to live. I believe new technology is the answer to a strong economy where we have people working and where we can move forward just as business can do, if they really decide that they are not going to simply draw in their necks.

Mr. Fuqua. Thank you very much, Berk. You certainly, I think, outline the really critical situation we are in. I certainly want to forgive you for any past transgressions on the support of the space program. But you know, of all the money that was spent, not one dollar was spent on the Moon; it was all spent right here, not only providing jobs but, as you point out, new technology and things we can use for the future.

As you further point out, at a time when we are in a critical situation, where we should move forward technologically, we find ourselves laying off sales forces. There is no company that can survive—you are absolutely correct—in the long term that way. Short-term, you can maybe get by, but in the long term I think we are just eroding our base. As has been referred to many times, we are eating our seed corn.

Mr. Glickman?

Mr. Glickman. I just want to compliment Berkley on his statement and also for his recognition that our competitors are moving ahead in a broad variety of substantive areas that we traditionally have had the lead on.

You mentioned space. This week's Time or Newsweek has a story about what the West Germans are doing, and the European Economic Community, and the Joint Consortium on Space that will rival our space shuttle effort. In the area of aeronautics, which is near and dear to my heart since we make all these airplanes in my district, we are finding that the rest of the world is moving far ahead, primarily because their government has a rather cooperative, positive role with their industry that we do not seem to have.

Notwithstanding Dr. Keyworth's nice, positive, pleasing statements to the contrary, I do not believe that the real meaning of this administration's attitude toward science and technology is anything but negative, and it disturbs me very much.

Mr. Fuqua. Thank you.

We are very happy to welcome back one of our members who had a misfortune in an automobile recently in Maryland.

We are very happy to have you back with us—I was going to say hail and hearty, but I am not sure that would be the appropriate thing, but I know it is hearty, and we certainly offer our heartfelt thanks that you are back.

Ms. Bouquard. Thank you very much, Mr. Chairman. I want you to know that I appreciate your concern and the concern of the committee. It is good to be back, and I am sorry that I have had to miss some of our hearings.

I was rather appalled by a statement expressed by Dr. Saxon, president of the University of California, who said that he could not find any scientists that were willing to back up our commitment to CRBR. I would like to ask unanimous consent to submit questions in writing to Dr. Saxon to back up his statement in view of the support that our broad scientific community has given to this most worthy—in my opinion—project, since we are of course going to have to spend our money in the most prudent fashion.

It is good to be back. Thank you very much.

Mr. **Fuqua**. We thank you very much, Berkley, for your statement and taking your time to be here. I apologize for having to keep you waiting so long, but we thank you very much for your support and the problems that we are facing in trying to reach our long-range goals of technology and basic research. Thank you very much.

Mr. **Bedell**. Thank you, Mr. Chairman.

Mr. **Fuqua**. The committee will be adjourned.

[Whereupon, at 12 noon, the hearing was recessed, subject to the call of the Chair.]

U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS

WEDNESDAY, FEBRUARY 3, 1982

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to call at 2 p.m., in room 2318 of the Rayburn House Office Building, Hon. Don Fuqua (chairman of the full committee) presiding.

The Chairman. The committee will be in order.

Without objection, photograph and recording devices may be used during the course of the hearing.

The committee meets this afternoon to continue its series of hearings on U.S. Science and Technology Under Budget Stress. What we are concerned about in these hearings is to examine the administration's policies for federally supported research and development and their impact on our Nation's scientific and technological capabilities.

Here is the overall budget picture thus far: From 1980 to 1982 the Federal nondefense R. & D. budget has decreased by 16 percent in constant 1980 dollars. This is a serious situation. We are already aware of substantial program retrenchment in certain agencies and personnel layoffs at several major national laboratories.

We are looking across the board, from basic research to technology development, considering all areas of civilian R. & D., in order to get a general assessment of the situation before we receive the fiscal year 1983 budget request. The testimony we receive and the issues raised should help us in what promises to be difficult deliberations over the fiscal year 1983 R. & D. authorizations.

With us today are distinguished representatives from the scientific community, who will give us their assessments and recommendations.

It is a pleasure to welcome back before the committee Dr. D. Allan Bromley, who is now chairman of the board of directors of the American Association for the Advancement of Science. Dr. Bromley is also a distinguished professor of physics at Yale University.

We also welcome Dr. Robert W. Parry, who has just recently become president of the American Chemical Society. Dr. Parry is also an eminent chemistry professor at the University of Utah.

We are especially honored today to have Dr. James Watson, a leading member of the prestigious Delegation for Basic Biomedical Research. Dr. Watson, as many of you know, is a Nobel laureate renowned for his pioneering work on DNA, and he directs the famous Cold Spring Harbor Laboratory on New York's Long Island.

Representing the American Institute of Biological Sciences, we are delighted to have Dr. A. Carl Leopold, a senior scientist working in plant physiology at the Boyce Thompson Institute in upstate New York.

We want to welcome all of our distinguished witnesses this afternoon. As has been the practice, we will hear from the witnesses and then try to relate questions to all of you, otherwise we will be here until tomorrow with the interest shown by the membership.

As our first witness we will start with Dr. Bromley.

[The biographical sketch of Mr. Bromley follows:]

BIOGRAPHICAL INFORMATION OF D. ALLAN BROMLEY, PRESIDENT, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

D. Allan Bromley (physics), 1926; B.Sc., 1948. M.Sc., 1950, Queen's University; Ph. D., University of Rochester, 1952; M.A., Yale University, 1961; Dr. Nat. Phil., University of Frankfurt, 1978. With Yale University since 1960; Henry Ford professor since 1972; director, A. W. Wright Nuclear Structure Laboratory, since 1963. Previously with University of Rochester and Atomic Energy of Canada, Ltd. Fellow, American Academy of Arts and Sciences; Governor General of Canada Metal, 1948; National Research Council fellow, 1952; Guggenheim fellow, 1977-78; Humboldt fellow, 1978; Benjamin Franklin fellow, Royal Society of Arts, 1979; Council, American Physical Society, 1967-71; chairman, Physics Survey Committee, National Academy of Sciences, 1969-73; chairman, Office of Physical Science, NRC, 1975-78. Vice president, International Union of Pure and Applied Physics; chairman, National Science Foundation committee to review university based nuclear science laboratories; chairman, CSPRC Delegation in Nuclear Science to China; United States/U.S.S.R. Working Groups on Science Policy and on Research on Fundamental Properties of Matter. AAAS activities: chairman, Section on Physics, 1978; Council, 1979; President-Elect, 1980; President, 1981.

STATEMENT OF D. ALLAN BROMLEY, CHAIRMAN, BOARD OF DIRECTORS, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AND PROFESSOR OF PHYSICS, YALE UNIVERSITY, NEW HAVEN, CONNECTICUT

Mr. **BROMLEY**. Good afternoon, Mr. Chairman.

Mr. **FUQUA**. I might add also that if you wish to make your statement in its entirety part of the record and summarize it, we will be happy to receive it in that fashion also.

Mr. **BROMLEY**. Thank you, Mr. Chairman. I want to begin by thanking you and members of the committee for the opportunity to appear before you again as you continue your series of hearings on U.S. Science and Technology Under Budget Stress.

I have submitted a rather more complete testimony than usual for the record, Mr. Chairman, because I felt that the questions you addressed to us were particularly penetrating and difficult ones, and that they deserved rather detailed answers.

So, with your permission, I will submit the testimony for the record, and provide here only highlights. To help you in this, I have made available to you a summary of those highlights, and I will be speaking from that summary. By way of a general overview, I should like to summarize a number of my views. Some of these I will address later today. Others will be followed up in greater detail in the formal testimony.

OVERVIEW

Let me start by simply emphasizing that overall, we still have in the United States the world's strongest science and technology enterprise, although I sense that that strength is in some jeopardy.

It is also a time of very rapid change in the legislative and executive branches of the Government, in science and technology themselves and in public expectations.

One of our major tasks is that of building a new constituency and greater understanding of science and technology.

I would argue we must uncouple the research and development aspects of R. & D.; and would advocate that under almost any national scenario, modest real growth in Federal support of long-range research is an essential investment in our Nation's future.

We must rebuild science and mathematics in the Nations' schools to foster both public literacy and foundations for professional development.

Whatever we may eventually decide regarding the optimum mix of our research and development institutions, and whatever we may decide as a Nation to do in response to current personnel shortages, I should like to urge that we not embark on crash corrective programs, but rather make changes consistent with the time constraints of the systems involved.

We have to rebuild the bridges between the scientific and engineering communities and the national security and defense enterprise.

We must also rebuild bridges between the scientific and engineering communities and private industry, and help focus our attention on the international, as opposed to the national marketplace.

We must act and be perceived as acting to better the quality of life in the Third World and we must maintain a major role in the international science and technology community.

We must face up to the fact that there are areas where science and technology may appear to be on a collision course with the democratic process. We have to address these issues openly and intelligently, and do so now.

Finally, those of us in the scientific and engineering communities must do a better job of working together, and we must do a better job of working with you, Mr. Chairman, and your colleagues in the political world.

FEDERAL ROLE R. & D.

Let me then turn to the question of the Federal role in research and development. It is important to recognize that the principal support of basic research for 40 years has been a public responsibility, and I believe that it must remain one.

The private sector will not necessarily allocate optimal resources in all the areas that are of importance to the Nation. There are several reasons for this. First of all, the overall benefits are distributed much more widely beyond the institution that pays for the work. Second, long range research is inherently risky. Third, the scale of investment in instrumentation required to reach the frontiers (for example, telescopes, accelerators, phytotrons, large electron microscopes) is such as to be beyond the means of all but the very largest private organizations. Finally, in this area, current management philosophies in this country that place emphasis on short-term payoffs seem to me, to mitigate against long-term investment and research.

And so, I conclude that the issues of supporting investment in basic research should be separated from those relating to development. The Federal role in the development process is often debatable in terms of specific projects. But modest real growth in Federal support of basic research I believe to be central to our national well-being in the future.

National security and defense matters are also a vital part of the Federal role. The relationship between science and the military goes back a very long time, to the very beginning of our Nation.

But, the major buildup occurred only during and after World War II. All of us in the Nation, particularly in the scientific and engineering communities, owe a very great debt to people like Robert Conrad, Mannie Piore, and other people in the Office of Naval Research who formed a pluralistic mechanism that has served this Nation well and has been the envy of the world. It bears emphasis that during the 1950's the Department of Defense was the dominant supporter of basic research and of university research in this country.

We all know about the influences that arose during the 1960's and 1970's to separate the military from the universities. There were the antiwar, the antitechnology movements that grew in the shadow of the Vietnam conflict external to government. And within government there was the Mansfield amendment.

As I view the Federal role I see the need for close and enduring relationships between scientists and engineers on the one hand, and those in the military forces on the other. Yet, we must recognize that there are inherent tensions here. National security often calls for secrecy. Science almost always calls for open communication. Devising the appropriate balances here will surely be one of the most vexing and challenging questions in an open society such as ours.

Private sector relationships are also part of the Federal role. Prior to World War II, as we all know, the private sector was the dominant supporter of academic research in the country. But with the availability of generous Federal support flowing after the war, this role dwindled.

It seems to me the private sector must continue to play a large and complementary role to the Federal Government in supporting basic research. Both industry and the research community have much to gain from this. A rebuilding process is long overdue in this private sector—university interface. And happily, it is underway. It reflects a greater recognition by the private sector of its needs. It also reflects recognition in academia, belated recognition, of its needs for private support, and beyond private support for the philosophy and the real world input from industry. I happen to believe that these latter contributions more important even than the direct support.

The private sector-Federal interface reflects many of the same problems, and further displays a myopia about international competition. Other governments work closely with their companies to make them more competitive, usually with us, in the international marketplace.

Until recently, our Justice Department, however, has been seeking to break up firms like IBM and the Bell System with international competitive R. & D. capabilities. The time has come for us to think through what we are trying to accomplish.

And because of these things it is a matter of serious concern, I believe, to us in the United States to recognize that the fraction of the scientists and engineers in the U.S. labor force has declined steadily since 1965, while in the same period this fraction has doubled in both Japan and in Germany.

I would argue that this is not at all unrelated to trends in productivity. In my formal testimony I have argued that the Federal role in R. & D. is really a set of complex issues which demand close study. New kinds of partnerships must be developed between those concerned with national security and those in the universities. It will not be easy.

Similiarly, we must evolve a broadened partnership among universities, the Federal Government and the private sector. It is essential to our economic growth and improved international competitive posture. And while part of this deals with budgets and with policies, a very important part of it is related to attitudes.

SETTLING PRIORITIES FOR DIRECT FEDERAL SUPPORT OF R. & D.

In your letter, Mr. Chairman, you asked for my comments on setting priorities for direct Federal support of R. & D. I am afraid I am going to pass this mostly back to you, because I believe that it really is more a political process than it is a scientific one.

Generally, I would have to argue for substantive science and engineering community influence on the aggregate size, the composition, the general directions for basic research, including that supported by the various mission agencies. I would argue, however, that the essential strength of U.S. science has been the fact that scientists themselves have in general decided what specific research projects should be conducted by which investigators. And the second real source of strength has been the multiplicity of our support agencies. But that multiplicity is decreasing.

The second priority is on development projects and of course is far more clearly a political task. Advice, can be given I would hope, from scientists and engineers on feasibility and alternatives, but nonetheless, development priorities are a political task.

And I will emphasize that priorities, both private and public, change very rapidly, and they should, in response to changing national and international pressures. But what should not change, at least anything as rapidly, are the criteria which underlie these priority decisions. What are we trying to achieve, and why? And I would urge that we devote more time than we have in the past to considering these criteria to arriving at a consensus concerning them. In my written testimony I have given some background information on an exercise in my own field of physics a number of years ago which might be in part illustrative.

But, let me conclude this part of my testimony by commenting that if there is a peculiar genius to the American political system, it is rooted in how you, Mr. Chairman, and your colleagues in the Congress and the occupant of the White House must finally come to grips with acceptable compromises on priorities. We scientists can offer advice to the President and to you, but we must acknowledge how the decisions are ultimately made.

POSSIBLE DAMAGE TO U.S. SCIENCE AND TECHNOLOGY

Another question that you asked me was that concerning possible damage to U.S. science and technology capabilities from actual reductions in support levels.

It is important to emphasize that some reductions were in plans and expectations.

For example in the Carter budget, some areas were slated for rather generous increases. These increases have been cut back in many instances. In many other cases we are faced with actual reductions in the programs involved. I am submitting for the record the most current analyses of actual budget levels and changes for R. & D. This is an AAAS report entitled, "Congressional Action R. & D. in the 1982 Budget," released a few weeks ago. It shows trends since 1980. Briefly, they can be summarized.

Defense research and development has increased 22 percent in constant dollars since 1980 while nondefense research and development has decreased by 16 percent. Overall, the conclusion can be simply stated: Except for defense R. & D. with two very minor exceptions, all agencies of the U.S. Government will experience an actual, that is constant dollar, reduction in total of R. & D. funding from fiscal year 1980 to fiscal year 1981.

And you ask what has been the damage? What damage would result if further reductions were made in the President's fiscal year 1983 budget, or by the Congress?

To take the second question first, I should emphasize of course that we don't yet know what the President's fiscal 1983 budget will be. If there are further reductions the damage will of course depend on where the cuts have been made and how deep they are.

With respect to the first question, what has been the damage? I should like to respond in two ways. First, I want to touch on several broad, general aspects. Then, I want to focus on a number of very specific issues that concern me particularly.

Among the general concerns are these: A number of fields of science and technology in the United States, fields essentially invented and developed to healthy maturity in this country, my own among them, are now at critical junctures. We have arrived at this condition after more than a decade of roughly level dollar funding, during which time we have tightened our belts, mortgaged our futures and often foregone high-risk studies. Relatively modest increases in investments would maintain U.S. activity at world frontiers; failure to make these investments now will drop U.S. activities back from the frontiers to positions from which it may take us years and major expenditures to recover.

It bears emphasis that, since World War II, primacy in all scientific fields has been a cornerstone of U.S. science policy. Yet, as I have noted above, and as acknowledged by Dr. Keyworth on a number of recent occasions, we are in the midst of changing this policy of primacy. It may well be, Mr. Chairman, that you and the administration, taking all things into consideration, will conclude that we have no realistic alternative to this in some cases. But, if this is the case, our retreat from the frontiers should be as a consequence of careful deliberation and decision, rather than some inadvertence or default.

And I am concerned, too, about some comparative perspectives. I don't intend to present a complete analysis. I do present more in my formal testimony, but here are a few key concerns.

Compared to Japan and West Germany, relatively we invest far less of our resources in civilian R. & D. directly oriented toward economic and social needs as well as the search for new knowledge. One reason for this is obvious. Their expenditures for defense R. & D. are minimal. Ours amount to more than 50 percent of our total expenditures and are growing. World military expenditures are now at a level of $550 billion per year, increasing at more than $50 million per day. We are carrying a large proportion of the defense load for the Western World.

Another matter of substantial concern is the fact that investment by U.S. industry in research measured as a percentage of U.S. industrial sales, has decreased by one-third between 1968 and 1980. And indeed, in summary, we are currently in this country investing a smaller fraction of our resources in our future than at any time since the mid-1950's. This I would submit to you is a source of serious concern.

Without attempting to minimize the seriousness of other impacts, I want to mention the following as ones of special concern to me. I have been privileged to testify before you on earlier occasions, sir, on some of these.

The first is international science activities. At a time when we should be participating even more extensively in the international scientific world, unhappily, just the opposite seems to be happening. When we are dropping back consciously from preeminence in international science and technology it surely is not the time to slam shut our window on the world. And a very special facet of the international scene is our set of ties with the developing world. Very special opportunties and problems arise here. They see science and technology as a means of achieving economic and social programs. It would seem to me that it would be a major mistake for us to forego these opportunities.

And much time and effort, Mr. Chairman, has been devoted by your committee, by many other groups in this country to the topic of science and engineering education. But I cannot pass by it. Briefly, let me summarize my concerns this way. Imaginative, creative people in a broad variety of scientific and engineering fields are essential in this country. But we have a very troubling and growing shortage of the right kind of people.

An adequate flow of the best young people into science and engineering enterprises must be maintained. But in too many areas the flow is ominously inadequate and decreasing.

In the latest National Research Council study on science and mathematics shows what can only be characterized as a dreadful state of affairs. There are limited offerings, few takers, and far less science and mathematics in our schools than in those of other countries. To continue, there are shortages of supplies and equipment for laboratory work, a very high level of drop-outs and illiteracy, decreasing SAT scores, and the litany goes on.

As I have emphasized elsewhere, we really are eating our seed corn, our high school science and mathematics teachers, as well as university faculty. A recent survey of the National Science Teachers Association also shows what can only be classified as a stunning drop in the number of those preparing to teach science and mathematics, more than 75 percent in the last 10 years, and an even worse drop in the number having trained for this work who have decided not to enter. That again is over 75 percent.

The private sector, happily, is already taking important and welcome remedial steps. They are not going to be enough. I would submit to you, sir, that there is an important role for the Federal Government, still, in science education.

Now I have to emphasize the fact that we are doing a miserable job of attracting women and minority group members into mathematics, science, and engineering. And this represents a talent lost that we simply can ill-afford.

But in the face of these rather dreadful statistics I am not calling for crash remedial programs. We need, instead, it seems to me, intensive examination of policies and Federal support of science education in the context of private sector and local roles.

Much that NSF did in the past with your help was good. And we should build on it. An important aspect of the whole science education area concerns public literacy in science and technology. It requires extensive attention on the part of all of us.

Instrumentation and facilities represent an area that we have talked about before. I would emphasize again, we must have modern competitive science and engineering facilities both for teaching and for research.

But in many areas and in many places throughout our country, our facilities are obsolete and noncompetitive. Even at high school level, in the areas of physical science and engineering, laboratory exposure is of critical importance. We are in terrible shape.

Within the last few years, shortage of equipment has dropped laboratory exposure in U.S. high schools by a factor of two. This is a situation we simply cannot tolerate.

If anything, the instrumentation situation in the American college and university world is even worse than in the high schools. In field after field, supposedly representing high technology frontiers, we are educating students with instrumentation frequently 20 and more years old, of another age, another generation. The instrumentation problem is serious in all physical science, but it is particularly serious in engineering.

And one of the areas of particular concern during the past year has been that of social and behavioral science. It has been of great importance during the last year that humanists and natural scientists throughout the country have been willing to speak up in defense of the social scientists.

There have been unprecedented and precipitous cuts in funding in vital areas of these fields. I would hope the arguments that have been advanced against these cuts will have some weight, and that the fiscal 1983 budget picture will be brighter.

But, I would submit to you that there is a unity to science that we will destroy or let perish only at substantial peril to the Nation.

IMPACT OF UNCERTAINTY AND INSTABILITY

You also asked me, sir, what the impact would be on the scientific and technical communities of uncertainty in budget revisions, and stability in the R. & D. planning and budget process. With your permission I would like to combine these questions in my answer.

First of all, I think it is terribly important for us to recognize immediately the fact that science and technology are inevitably shaped by the societies in which they are embedded. To expect immunity from the forces and influences, particularly political ones, at work in the society is not realistic. We are not suggesting that science and technology should be immune from these changes. Also, I would have to say that Presidents have a long history of changing their predecessor's budgets, and even their own.

But, having said that, let me emphasize that I certainly don't like uncertainty. I want to make some remarks about uncertainty and about variability in support of scientific research.

Most important of all is the fact that productive research groups are extraordinarily fragile entities. Once they are disbanded they can never be put back together again.

There is always, therefore, strong tendency in times of budget stringency to try to protect the group without too much reference to what the long-term costs of that protection might be. What are some of these costs. One of the early casualties in the protection system is usually foregoing development of new instrumentation, new devices, new techniques, and not doing the high-risk studies, with great potential importance but low success probability. Both of these cut deeply into the future of our science and into our effectiveness.

Other consequences are that uncertainty leads to short time horizons, limited expectations, a tendency to hunker down and hope that it will pass, and a loss of enthusiasm.

Over any extended period, extensive uncertainty is inimical to the very fabric and structure of research, and it strikes in the deadliest fashion against our investment in our long-range future.

Most of all, the damage occurs in areas of human resources. We already, as I have noted, face serious shortages in many areas. Uncertainty in research fields leads to loss of the best people in many of those areas.

Fields of science that have grown rapidly in the recent past can more readily accommodate leveling or even declines for a short time. But if I can take physical science and mathematics, the areas with which I happen to be most familiar, as examples, after more than a decade of essentially level funding when inflation has taken a heavy toll in our ability to do research and to train new scholars, I have to tell you that a weeding process has already taken place. Further reductions are not pruning away the less than excellent by any measure. They are cutting into our national excellence itself. We will pay a heavy price for this in our future.

Let me deal with the last facet of stability and change. Over the past four decades and more we have evolved in this country a complex mix of university facilities, national laboratories, industrial research organizations that has served us very well. Some, of course, have more effective internal renewal mechanisms than others. They are more able to respond to changing mission objectives and public expectations. I believe that, lacking adequate renewal and redirection mechanisms, some areas of our national research capacity are now seriously underutilized, at a time when we are very much in need of more and better research.

We have never felt it necessary to rationalize our present mix of institutions. They grew in response to local and immediate needs. But when our resources are in critical supply, with new and urgent demands for new research and new researchers are being made on the system, I believe that the time has come for us to undertake this rationalization. I have testified, Mr. Chairman, previously to you on this matter in the context of the national laboratories. And finally, let me say again that our goal must be that of supporting excellence, wherever we find it. The obverse is that in a time of limited resources and high competition we must never be satisfied with less than excellence.

In my formal testimony, Mr. Chairman, I touch also on science and society, and stresses other than from the budget. I shall not testify here in detail on this subject in the interest of time. But, let me only say that in working toward better public understanding of science and technology, it is important for us to keep in mind that there is a much deeper question involved. And that is, can science and technology be permitted to go their own way following their internal logic, without reference to decisions and to frameworks outside of science and technology? I think not.

Increasingly, and I have given examples in my testimony, the public is demanding to be heard in decisions that even now are entirely internal to science and technology. It seems to me that this is something that we in the scientific community, and something that you in the political world must recognize, and something that we must pay much more attention to in the future than we have ever done in the past.

Let me in conclusion, Mr. Chairman, thank you and your colleagues on the committee, both personally and on behalf of the AAAS for this opportunity to share with you a number of my concerns as we attempt to forge a new partnership that will insure the most effective growth and use of U.S. science and technology in a time of budget stress.

Thank you, Mr. Chairman.

[The prepared statement of Allan Bromley follows:]

Statement by

DR. D. ALLAN BROMLEY

Chairman, Board of Directors

American Association for the Advancement of Science

Introduction

Thank you for the opportunity to be with you again as you continue your series of hearings on "U.S. Science and Technology Under Budget Stress."

Since the FY 1983 Budget has not yet been submitted to you by the President, I will not be able to comment on specific budget numbers. Yet, based on what has happened to the FY 1982 Budget and various other developments I plan to offer a number of general observations and recommendations for your consideration.

But first, let me say just a few words about the American Association for the Advancement of Science--or the AAAS as it is commonly know. Our membership is about 136,000 scientists and engineers; as affiliates we have about 283 other scientific, engineering and technical societies and organizations--with a total membership of around 5 million. AAAS publishes the journals Science and Science 82, the latter with a circulation of about 750,000. The Association is also active in a broad variety of public policy, science education and public understanding of science activities.

Overview

You have already heard much testimony--starting in December 1981--and I have read the various statements carefully. You will find that on a number of basic points I am in agreement with Administration policy as presented by Dr. Keyworth on December 10th. At the same time, I would not be responsive to your request, Mr. Chairman, if I did not place before you certain areas where my views differ from the science policies of the Reagan Administration, as they have unfolded during the past 15 months.

By way of providing a general overview let me summarize a number of my views, some of which I will expand on later in my statement as I attempt to respond to the questions you asked in your letter of invitation:

- We still have, overall, the world's strongest science and technology enterprise, but this strength is now in some jeopardy.

- This is a time of rapid change--in the Legislative and Executive Branches of government, in science and technology and in public expectations.

- We must build a new public constituency and greater understanding for science and technology.

- We must uncouple the research and development aspects of R&D; and I would advocate that under almost any national scenario, modest real growth in federal support of long-range research is an essential investment in our future.

- We must rebuild science and mathematics in the Nation's schools to foster both increased public literacy and the foundations for professional development.

- Whatever we may eventually decide regarding change in the mix of our R&D institutions, and whatever we may decide to do in response to current personnel shortages, we should not embark on crash corrective programs, but rather make changes consistent with the time constants of the systems involved.

- We must rebuild bridges between the scientific and engineering communities and the national security and defense enterprise.

- We must rebuild bridges between the scientific and engineering communities and private industry and help to focus national attention on the international marketplace.

- We must act, and be perceived to be acting, to better the quality of life in the Third World, and we must maintain a major role in the international science and technology communities.

- We must face up to the fact that there are areas wherein science and technology may appear to be on a collision course with the democratic process and address these issues openly and intelligently now.

- Those of us in the scientific and engineering communities must do a better job of working together--and with those of you in the political world.

Organization of Testimony

You asked two sets of questions in your invitation letter. In responding, and with your permission, Mr. Chairman, I plan to recast them slightly. In the following order I will talk about the following topics, though my comments do not always divide neatly:

(1) Federal role in R&D.

(2) Setting priorities for direct federal support of R&D.

(3) Possible damage to U.S. science and technology capabilities from actual reduction in support levels.

(4) Impact on the scientific and technical communities of of uncertainty and budget revisions.

(5) Stability in the R&D planning and budget processes.

Federal Role in R&D

General: As I emphasized when I last met with you, it would be difficult to improve on a statement made by President Truman to a Joint Session of the Congress on September 6, 1945, only three weeks after V-J Day when he said:

> "Progress in scientific research and development is an indispensable condition to the future welfare and security of the Nation. No nation can maintain a position of leadership in the world of today unless it develops to the full its scientific and technological resources. No government adequately meets its responsibilities unless it generously and intelligently supports the work of science in university, industry and in its own laboratories."

The Nation has responded to this challenge. Currently some 70 billion dollars are spent annually, about equally divided between federal and private sectors, on research and development. This corresponds to about $315 per citizen. Basic research, of course, accounts for only about $36 per citizen. This latter is very probably the wisest investment that the citizen makes, even if few have any direct control over it or, indeed, ever think of it.

This linking of R&D has become traditional. However, it is essential, if we are to have informed discussions of the issues, that they be separated. The Reagan Administration is moving in this direction with its insistence that the private sector fund a larger share of development costs for technologies intended for civilian applications. As this occurs, it is important to recognize, and remember, as has been the case for forty years, that the principal support of basic research must remain a public responsibility.

Economists have repeatedly shown that the private sector will not necessarily allocate optimal resources to research in all areas that are of national interest. There are several reasons for this. It is widely recognized that the overall benefits to the Nation of much, though not all, long-range research and development certainly exceed the benefits to the organization that paid for it. By its very nature long-range research is risky; in many areas of science the scale of the instrumentation required to reach the frontiers--telescopes, accelerators, phytrons and the like--puts them beyond the scope of all but perhaps the very largest private sector organizations; and current industrial management philosophies in this country, with their emphasis on short-term evaluation and payoff, all mitigate against significant industrial investment in many areas of long-term research. Whatever the problems may be, it remains essential that R&D be separated and that basic research be discussed on its own merits as an investment in both the short and long-term future of this Nation.

Because you have asked for my views, let me state explicitly my belief: even if we find ourselves with lesser growth--or even reduction--in our overall R&D investments for the near term (and emphasizing my obvious conflict of interest here), I would be less than candid if I did not emphasize to you in the strongest terms my conviction that we should plan for modest, continuing real growth in our research (R) activities, even at the cost of corresponding reductions in our development (D). This would represent true investment in our national future and the most cost-effective one of which I am aware.

A number of fields of science and technology, fields essentially invented and developed to healthy maturity in this cournty--my own among them--are now at critical junctures. We have arrived to this condition after more than a decade of level dollar funding, during which time we have tightened our belts, mortgaged our futures, and often foregone the high risk studies. Relatively modest increases in investments would maintain U.S. activity at world frontiers; failure to make these investments would drop U.S. activities back from the frontiers, to positions from which it may take us many years and major expenditures to recover.

It may well be that you, Mr. Chairman, and the Administration, taking all things into consideration, will conclude that we have no realistic alternative to this in some cases. But if this isn't the case, our retreat from the frontiers should be as a consequence of careful deliberation and decision, rather than some inadvertence or default.

And no contemporary discussion of the federal role would be complete without mention of accountability. No responsible member of the scientific community questions for a moment the obligation to account for the support received from the taxpayer. But the premise that scientists must beheld to the same accounting standards as hourly workers is one that deserves much more attention and discussion than it has received thus far. Obviously, accountability is not a subject new to you; the pressures in this place in recent years have led to more, and not less. But we may have reached the point where we should question more deeply what it is that we are trying to achieve with incessant demands for more control and more accountability.

National Security and Defense: It is impossible to comment on the Federal role in R&D without a brief look at national security and defense. Indeed, it is often difficult to remember that prior to the 1930's, and really to World War II, natural philosophy--understanding the universe--and mastery of nature--invention--were almost entirely separate endeavours. With the radar and Manhattan projects of World War II this separation--for better or worse--was gone forever. However, use of technology for military purposes, is nothing new; indeed it marked the earliest contact, in our history as a Nation, between the Federal Government and the university community. During the 19th Century there were numerous fruitful contacts between the military and the universities.

Yet, not until World War II did the large-scale, sustained build-up in the relationships between defense and the universities occur. The Nation, and science and engineering in particular, owe an enormous debt to individuals such as Robert Dexter Conrad, Emanuel R. Piore and other early postwar administrators of the Office of Naval Research for forging a pluralistic, and enlightened federal support mechanism for research and development that served us well and that has been the envy of the world. Not only did academia and the private sector benefit enormously from support of their research activities but also the Navy benefited equally from day-to-day contact with some of the Nation's most able citizens and with some of its brightest young people.

The other Services were somewhat later but they, too, developed effective linkages with the research community. In the army it was Dwight Eisenhower who urged these linkages; in the Air Force it was General Curtis LeMay. Thus it came to pass that during the 1950's the Department of Defense was the dominant supporter of U.S. academic research.

When it was finally established in 1950, after extended and frequently bitter discussion about the extent to which scientists themselves should control it, the National Science Foundation Act of 1950, passed by the 81st Congress on May 10 of 1950, had as its preamble the following:

> "An act--to promote the progress of science, to advance the national health, prosperity and welfare; to secure the national defense; and for other purposes."

Clearly, this envisions a broad role for science, specifically including national defense. Indeed, Section 3(a)3 of the Act read as follows:

> "(3) At the request of the Secretary fo Defense, to initiate and support specific scientific research activities in connection with matters relating to the national defense by making contracts or other arrangements (including grants, loans and other forms of assistance) for the conduct of such scientific research."

Subsequently, this section was formally deleted from the NSF Act--a step in the direction of separating science specifically related to defense from questions regarding the general support of science.

This separation continues, and was greatly accelerated, by two events in the 1960's and early 1970's. Evolving inexorably during the 1960's, U.S. involvement in the Vietnam conflict triggered violent anti-military and, secondarily, anti-technology, sentiments across the Nation, but particularly on university and college campuses. The resulting, often dramatic separation of the universities and the DOD hurt both.

In 1969, following hard on this, Congress enacted a rider the Military Authorization Act for fiscal year 1970 (Public Law 9--121, Section 203)--the so-called Mansfield Amendment, reading as follows:

> "None of the funds authorized to be appropriated by this Act may be used to carry out any research project or study unless such a project or study has a direct or apparent relationship to a specfic military function or operation."

The following year, the language of Section 203 was modified in response to general recognition that the original Mansfield Amendment was counterproductive and Section 204 of Public Law 91-441 read:

> "None of the funds authorized to be appropriated to the Department of Defense by this or any other act may be used to finance any research project or study unless such project or study has, in the opinion of the Secretary of Defense, a potential relationship to a military function or operation."

In a follow-on Section 205, the Congress affirmed the necessity for Federal support of basic scientific research, and went on record that the National Science Foundation should assume a large share of such support.

Passage of the original Amendment was necessarily followed by detailed examination of the research portfolios supported by each of the DOD program officers, and a very large number of very high-quality research projects were deemed not to meet the requirements of the Amendment, as strictly interpreted, and lost DOD support. Projects totalling 8 million dollars were dropped.

Today there are different views about the legal status of the Mansfield Amendment; some argue that it is still in effect while others argue that it was repealed with the substitution of "potential" for "direct and apparent."

Whatever the exact legal status of the Mansfield Amendment may be, a vastly more effective entity, the "ghost Mansfield Amendment," is firmly in place and both it and the actual modified Amendment still influence DOD funding decisions. The "ghost" Amendment describes this situation: program officers, having been once held responsible for dropping research projects not obviously having a "direct or apparent" relationship to DOD missions, as required by the original Amendment, were reluctant to consider, if not adamantly opposed to, rebuilding programs in such areas. This attitude persisted despite the modification of the Amendment and quite concrete and repeated pronouncements by higher officials in the DOD in one Administration after the other--to the effect that DOD was back in the business of supporting long-term basic research, was interested in rebuilding bridges to academia, and the like. The program officer reaction was a quite understandable one.

But the time to rebuild these bridges is long overdue. In a democratic society, such as ours, it is essential that those responsible for national security and defense neither be, nor feel, cut off or isolated from the general society. And at a time when the DOD R,D,T&E budget has been increased by more than 6 billion dollars--by 47% since 1980--and when it is experiencing an urgent need for manpower able to cope with ever more sophisticated weapons systems, it is essential for both the universities and the DOD that they establish new relationships and interactions. It will require goodwill and flexibility on both sides.

All too frequently, discussion of DOD manpower needs focuses on research and engineering personnel. While serious shortages exist in these areas, an equally critical question is whether we can produce high-school graduates with sufficient background and scientific and technical literacy so that they are trainable in the military services to maintain and operate the complex weapons and communications systems now in place and on the drawing boards. It is time that DOD accepted part of the responsibility for strengthening sceoncdary school education.

For decades the military services have provided personnel and equipment for ROTC programs in both high schools and colleges. Perhaps there is a comparable way in which the services could provide scientific equipment and scientifically trained personnel to supplement existing capabilities in at least selected secondary school systems.

As I view the federal role in regard to science and national security I see the need for close and enduring relationships between scientists and engineers and those in the military forces. Yet we must recognize inherent tension in these relationships: national security often calls for secrecy; science almost always calls for open communication. Devising the appropriate balances is surely one of the most vexing--and challenging--questions in an open society such as ours. Hyperanxiety on the part of government officials, and that of scientists, must be avoided lest we fall into twin idiocies: attempting to hide all knowledge on the one hand--or eliminating research of importance ot national security from the university world, as we attempted to do in the late 1960's and early 1970's, on the other.

Private Sector Relationships: The federal role in R&D must also be seen in the context of private sector roles; they must be viewed as interconnected. Prior to World War II, support from the private sector played a dominant role in academic research and in research generally. With generous postwar federal support flowing from scientific and technological triumphs during the war years, however, the private sector support for academic research dwindled in visibility and perceived importance.

Galloping academic arrogance also contributed to the destruction of the bridges between academia and the private sector. All too often these bridges were replaced with mutual ignorance and suspicion.

The rebuilding process is long overdue and, happily, is in progress. In part, this reflects the private sector's recognition of its desperate need for bright young people and for new and better technologies if it is to remain competitive in the international marketplace. In part, it also reflects academia's belated recognition that it needs both financial support and real-world input for its research and teaching activities as well as career opportunities for its graduates.

While the emphasis has largely been on the first and last, I believe that the real world input is of greatest importance. Only through interaction can the stereotypes be destroyed. I believe, for example, that over the years the content of our college and university educational programs has remained of high quality but the attitudes that have been inculcated have frequently been very questionable. Much of an entire generation of graduate students in science gained the impression that first-class citizenship implied replication of ones professor's laboratory and program with all speed, while second--or perhaps third class--citizenship was the best one could hope for in any industrial milieu. Such attitudes carry low survival potential in today's world.

U.S. industry has been relatively slow in coming to grips with the international marketplace after decades of easy dominance of both national and international scenes. All too frequently the entire focus has been on national needs and opportunities; the federal-private sector interface still largely relects this myopia. While foreign governments aid, abet and even organize cartels so that their industries can compete more effectively (usually with us) on the world market, our Justice Department, until recently, has worked at at breaking up entities like IBM and the Bell System that are large enough to support the level of R&D that makes them highly competitive internationally.

During the 1977 AAAS R&D Policy Colloquium, several speakers reported that technological advance, the growth of knowledge, has been second only to the labor supply increase as a major source of U.S. economic growth over both the short and the long term since 1929. At this same colloquium William Nordhaus, then a member of the Council of Economic Advisers, told us that most economic analysts were convinced that "The role of research and development in technological change in the economy is paramount."

It is then a matter of concern to find that the fraction of scientists and engineers in the U.S. labor force has declined steadily since 1965, while in this same period the fraction has doubled in both Japan and Germany. I would argue that such trends, at least, partially explain national productivity results of the past ten to fifteen years.

Between 1961 and 1978 the annual productivity gain in manufacturing averaged more than 9% in Japan, 5% in Germany and 3% in this country. Total U.S. private sector productivity has actually declined in recent years. More graphically, the Japanese outproduce us by a factor of 15 when making motorcycles and by a factor of 2 when making either steel or pianos. And their quality is frequently superior to ours.

There are may facets to the productivity question--capital investment, management, human resources and research and development to name only four. In capital investment per capita, in 1963 we ranked first in the world; by 1975 we had slipped to sixth place behind Norway, Canada, Sweden, Switzerland and France. More recently, Europeans have been increasing their per capital investment in industrial plant and equipment by 4% per year, Japanese and Koreans report 10% per year while our corresponding number is 2%.

William J. Abernathy, of Harvard, has also suggested that we have educated a generation of MBA industrial managers to believe that in order to remain on the "fast-track" they must change corporations every 3-4 years and that any investment with a longer payoff will inevitably benefit their successors rather than themselves. This is not conducive to the strong support of long range industrial R&D or significant productivity increases.

In July 1981 the AAAS sponsored--together with the House Task Force on Industrial Innovation and Productivity and the Committe on Science and Techonolgy--a Congressional seminar on the human resource facets of productivity. Research results presented to the Congress in this seminar, and in subsequent hearings, pointed to the need for greater attention on the "people" part of productivity. Henry Ford II has also noted that the largest untapped potential for improvement in industrial productivity in this country is the American worker.

All of these questions bear close study. But industry has already recognized that its future depends critically on more and better science and engineering. The partnership among universities, industry and the Federal Government that is essential to economic growth and improved interntional competitive posture is now under construction. The soundness of that construction and its success should be matters of deep concern to every citizen.

Setting Priorities for Direct Federal Support of R&D

Your letter asked for my perspective on how to set priorities for direct Federal support of R&D. I think that mostly I am going to pass this one back to you; essentially, this is a political process rather than a scientific one. Yet, I do not wish to appear non-responsive.

As a generalization, I would argue for substantive science and engineering community influence on the aggregate size, composition, and general directions for basic research--including that supported by the various mission agencies. Moreover, I would also argue that an essential strength of U.S. science has been that scientists themselves have primarily decided what specific research projects should be supported by which investigators.

It is sometimes said that scientists have no mechanisms for setting priorities; this, of course, is wrong because each scientist makes numerous decisions concerning how best to spend his time and resources over the weeks and months ahead. These are immediate priority decisions; other decisions about lines of inquiry, opportunities, and emerging fields tend to be longer-term priority decisions. But there is a very important point here: priorities, no matter how carefully drawn or developed, can change almost instantly. In our own personal lives, priorities change radically. So also do national priorities in response to changing national and international pressures.

But what should not change, if properly developed, are the criteria upon which priorities should be based. I believe that we should devote much greater emphasis than we do to development of a national consensus as to what our criteria should be. For areas of science and technology, we should examine what are we trying to accomplish and why. Only with basic criteria in hand, do I believe that our priority decisions will be informed, useful and effective.

Roughly ten years ago, I had the privilege of chairing the National Academy of Sciences' Physics survey, one of the most ambitious studies in the field of science ever undertaken. During the study we devoted substantial efforts to the development of criteria for the selection of areas of our science for preferential emphasis and support. Obviously, the questions become more difficult as we move beyond the boundaries of a single science. But as an illustration of criteria development, I include the physics criteria established in the study as an appendix to my testimony.

For large technological projects, priorities must be set by politicians in the context of national objectives. Here, the roles of scientists and engineers should clearly and distinctly deal with advice on such matters as feasibility, alternatives, risk assessment, and potential pay off.

But the world seldom presents clear choices--and, if there is a peculiar genius to the American political system, it is rooted in how you in the Congress and the occupant of the White House must finally come to grips with acceptable compromises on priorities. We scientists can offer advice to the President and to you, but we must acknowledge how the decisions are ultimately made.

Sometimes, scientists and engineers are "like babes in the woods" when it comes to this complicated decision process. I was very much struck with the advice that one of your former colleagues gave in remarks at the 1980 AAAS R&D Policy Colloquium. Bob Giamo, then Chairman of the Budget Committee, said this in a remarkably candid and illuminating talk:

> "You have to fight harder for your own programs because you now competing with other people in the United States who are fighting unusually hard for thier programs. If they win you are going to lose--and vice versa. This is a new phenomenon in Washington."
>
> "You have to work doubly hard because, while I understand the importance of R&D, I can tell you that you are competing with school lunch subsidies, and postal services and social security pensions and with twice a year cost of living adjustments as opposed to once. And while you may have a pretty good lobby and while I know that you are articulate, you don't have the numbers that some of the others do and you don't scream and raise hell as well as they do."

Possible Damage to U.S. Science and Technology Capabilities From Actual Reductions in Support Levels

Another question you asked me to discuss was the possible damage to U.S. science and technology capabilities from actual reductions in support levels.

We all know that in the past year there have been many substantial reductions in federal support for research and development. Some of the reductions were primarily reductions in plans and expectations for new programs which would have required substantial funding increases. Many of the reductions in President Carter's FY 1982 budget made by President Reagan last March are in this category. Other reductions actually forced major project cancellations and major changes in plans.

The most up-to-date survey of the actual changes in budget levels for R&D is in the AAAS report "Congressional Action on R&D in the FY 1982 Budget," prepared at the end of December and released early in January. This report estimates the following trends in federal support of R&D from FY 1980, the last year for which firm figures are available, to FY 1982:

- Total non-defense R&D is about level in current dollars, but is down 16% in constant dollars.
- Total defense R&D is up 45% in current dollars and 22% in constant dollars.
- Total basic research is up 13% in current dollars but down 5% in constant dollars (in spite of a 6.6% real increase in defense basic research).

Tables 3 and 5 of the AAAS report, which I will submit for the record, give the details of these trends by federal agency; further details are given in the report itself. The conclusion can be simply stated: except for defense R&D (and one minor other exception) all agencies of the government will experience an actual (i.e. constant dollars) reduction in total of R&D funding from FY 1980 to FY 1982.

What has been the damage? What damage would result if further reductions are made, in the President's FY 1983 budget or by Congress?

To take the second question first, I should emphasize that we do not yet know what the President's FY 1983 budget recommendations will be. If there are further actual reductions, the damage will of course depend on where the cuts have been made and how deep they are. We will learn more about this during the next few weeks as we begin our work on analyzing the budget.

With respect to the first question, "what has been the damage," I should respond on two levels. Let me begin by focusing on certain general questions. Later in my testimony I shall return to the question of specific damage to science, with particular reference to the effect of long periods of essentially constant dollar funding in and inflationary environment. I shall first focus on the impact of the FY 1982 budget reductions. Without minimizing the seriousness of other impacts I want to mention the following areas of difficulty as of special importance and as ones which I shall discuss later in my testimony:

- Science and engineering education
- Instrumentation and facilities
- Areas of social and behavioral science
- International science activities

In any such discussions, however, it bears emphasis that the Congress has appropriated a lot of money for R&D--$40 billion for FY 1982. The numbers here are large. William D. Carey, Executive Officer of AAAS, has estimated that over the decade of the eighties, government and industry in this country will spend about one trillion dollars on research and development. However, support numbers in the billions and even trillions of dollars cannot be examined in isolation and, indeed, can be misleading. The sheer size of the U.S. economy results in larger R&D expenditures than those of other countries; it is in comparative perspectives that the serious concerns arise. Also, in certain sectors of R&D and in some special areas there are problems which should cause us to be disturbed--if not alarmed.

Summary of Immediate Budget Outlook

We are likely to see a total R&D amount for FY 1983 in the range of $43-44 billion--with the largest increase being in the defense category. The slight decline in non-defense R&D (current dollars) between FY 1980 and FY 1982 is not likely to be significantly offset by FY 1983 increases. Short of a major confrontation between Congress and the Reagan Administration, these trends are likely to continue for the next 2-3 years.

In following sections I discuss a number of policy issues tht go beyond budget numbers--and outline for you some of the areas where I am especially concerned.

Comparative Perspectives. I don't pretend to provide you with an extensive comparative analysis, but here are some factors that we should look at:

- Compared to Japan and West Germany, relatively we invest far less of our resources in civilian R&D which is directly oriented toward economic and social needs as well as to the search for new knowledge. One reason is rather obvious. In recent years Japan has allocated only 2% of its governmental R&D expenditures for national security and defense, West Germany about 12% and France 30%; we have been investing about 50% of our R&D funds in this sector and this fraction is growing. World military expenditures now are at the level of 550 billion dollars annually and this is growing at a rate of more than 50 million dollars per day. We are carrying much of the defense load for the western world.

- Our total expenditures on R&D, considered as a percentage of our Gross National Product, have been declining steadily since the middle 1960's--from 2.97% in 1964 to 2.27% currently; we may have the first slight upward trend in 1981. In contrast, the Japanese percentage in this same period has risen from 1.48 to 1.93% and the West German percentage from 1.57 to 2.36% --now above ours.

- Investment by U.S. industry in research, as a percentage of U.S. industrial sales, has decreased by one-third between 1968 and 1980.

- Indeed, we are currently investing a smaller fraction of our resources in our future than at any time since the mid-1950's. This must be a source of serious concern.

Major Policy Issue: What Kind of Leadership. One of the toughest issues before you is "What Kind of Leadership Role Does the U.S. Intend to Maintain?"

Following World War II, in almost every area of scientific research and development, U.S. activity established the framework and set the pace for world activity. Pre-eminence in all fields was both an explicit and implicit cornerstone of our national approach to science and technology.

In talking aobut comparative perspectives in a different way, it was, perhaps inevitable that our pre-eminence has changed in one area after another of modern science, in particle and nuclear physics in Western Europe, in computer science in Japan, in applied mathematics in the Soviet Union, for example. Other countries, by focusing their resources, have mounted salients in these and fields that are equal to, if not indeed ahead of, ours, although as I have emphasized above, we still have a commanding overall lead.

The Reagan Administration is the first to explicitly recognize this changed situation. In his remarks in the 1981 AAAS R&D Colloquium, and in similar words presented to you in testimony last December 10th, George Keyworth said:

> "Undoubtedly, our country has relinquished its pre-eminence in some scientific fields, while others are strongly threatened through efforts in Europe, Japan or the Soviet Union. It is no longer within our economic capability, nor perhaps even desirable, to aspire to primacy across the spectrum of scientific disciplines. The contraints of reality require discrimination and vision, attainable only through a collaboration of the government and the scientific and engineering communites. It is simply unreasonable for us to expect to be best in everything."

As we engage in the debate on this major policy change, a number of considerations arise which are discussed in subsequent sections.

Policy Implementation. Shall we consciously yield in certain fields or sub-fields of science? What new, if any, mechanisms shall be employed to make such decisions? We need, I would argue, to think through the implications of this explicit policy--given the strong likelihood that economic factors will force its further implementation.

International Science and Technology. Proceeding with such a policy calls, all the more, for full U.S. participation in the international scientific and technological community--one which is perhaps the only community that fully transcends political boundaries and one in which we have played a major role since World War II. Sharing and international exchanges will be even more essential than they have been in the past.

Unhappily, just the opposite seems to be happening. Current budgetary limitations have already forced likely cancellation of such international projects as the U.S. European International Solar Polar space mission--to the consternation of our European colleagues. Similar limitations on NSF budgets for international activities will require sharp curtailment of our participation in such bodies as the International Council of Scientific Unions and its member disciplinary unions. And the views from the Defense Department would suggest strong pressures to reduce drastically international exchanges. It would seem that when we are falling back from pre-eminence in international science and technology, it is surely not the time to slam shut our windows on the world!

Another dimension of the complex mixture of cooperation and competition on the international scene deals with public-private sector connections. We have never attempted to focus or jointly plan governmental and private sector science and technology in ways that are commonplace throughout the developed world. We have never felt a need for such planning, but as we reexamine our changed role in the international economy, total laissez-faire may be a luxury we can no longer afford. The role of MITI, the Ministry of International Trade and Industry, in orchestrating the Japanese national and international activities, for example, is one we can no longer ignore. If we are to be competitive in the international marketplace, it would seem that reexamination of the policies, laws, and traditions controlling the interactions of our industries, our universities, and our Federal Government is long overdue.

Ties with the Developing World. Very special opportunities and problems emerge in our interaction with the developing world which sees the application of science and technology as a major means of achieving economic and social progress. It would be a major mistake to forego these opportunities because of internal domestic pre-occupations.

It bears emphasis that, using World Bank statistics, in 1973, the average GNP per capita (in U.S.dollars) in North

America and Japan--the most affluent two sub-areas considered--was \$5340, while in Africa and Asia (excluding Japan)--the least affluent two sub-areas--it was \$215. The ratio here is 24.8. In 1978, after five years of active discussions and projects directed toward reduction of the ratio, the two corresponding numbers were \$9029 and \$328, and the ratio was 27.5. The gap between the most and the least affluent had widened; it continues to do so.

All of us in the developed world share, to a greater or lesser degree, the humanitarian desire to improve the quality of life of those less fortunate than ourselves. With the advent of satellite communication links and bicycle-powered TV sets in even some of the most remote villages, however, there has been a qualitative change in our interaction with much of the Third World. Prior to this change, few in that world realized that we, and many like us, enjoyed a quality of life beyond their wildest imagining; but having seen and appreciated this distinction, Third World expectations have taken a quantum jump. And unless we act, and are perceived to be acting to better their lot, we run the serious risk of a world in turmoil, with the developing world making common cause to fight for what they view as a fairer share of the earth's resources. In this sense, OPEC may be only a pale precursor of worse things ahead.

Aside from humanitarian desires for generally making the world a better place for all, there are additional reasons for arguing that it is in the best interest of the United States that we help in the utilization of science and technology for Third World development. We export more goods and services to Third World countries than to Western Europe and Japan combined.

It is possible to agree with President Reagan in calling for significant reliance upon the private sector; however, I also think this is one of those areas--mentioned earlier--in which concerted government-private endeavors will be superior to those of either acting alone.

As a specific suggestion, except in very special cases, it appears to me that we would be well advised to change the focus of our interactions with the developing world from a preoccupation with technology-transfer (to the usual extent that this implies high-technology) to include a more balanced consideration of science-transfer as well. We can and should--and at much reduced expense--assist developing nations to develop educational structures--in which science and technology would appropriately receive considerable pragmatic emphasis. And most important, we must help the developing world to create challenging and rewarding career opportunities for their most able and highly trained citizens at home. Only by retaining a large fraction of their best people--which is certainly not now the case--can they hope to develop a stable and growing educational system and a pool of educated persons who can function as midwives and developers for the future transferred technologies fundamental to economic growth and stability.

In our long-term best interest, we must forego the short-term advantages of the continuing brain drain wherein our universities and hospitals are increasingly populated by the best minds we can find anywhere in the world. And we must make it in the individual's best interest--both personally and professionally--to build a career at home.

Here, again, we must be much more sensitive to the special needs of other countries, other cultures, other systems than we have been. Whether overtly or not, much of our interaction with the rest of the world has rested on the frontier assumption that "if it's good for us, it's good for anyone." Particularly has this been true in our interaction with the developing world. Increasingly, its members do not want to be told what to do; rather, they want us to help them do what they decide to do.

Special Concerns Affecting Our Strength. The comparisons noted above and my other comments on international aspects of science and technology provide a rather disturbing insight about what has been happening over time to our investment in the future. Let me reiterate that we still have, overall, the strongest scientific and technological establishment in the world--but we have have some very special problems, as Dr. Keyworth and others besides me have reported to you.

- We must have modern, competitive science and engineering facilities both for teaching and research--but in many areas and places our facilities are obsolete and non-competitive.

- Imaginative, creative people in a broad variety of scientific and engineering fields are essential--but we have troubling and growing shortages of the right kinds of people.

- An adequate flow of our best young people into our scientific and engineering enterprise must be maintained --but in too many areas the flow is ominously inadequate and decreasing.

In fact, I feel so strongly about our problems in science and engineering education that I intend to provide more testimony than you asked for. The problems go far beyond any one budget year and cut a wide swath through our Nation and its institutions.

A Science and Engineering Education Overview. Surely one of the greatest challenges, and at the same time one of the greatest opportunities, that we, as a Nation, face is in the area of education. It is an area to which AAAS has made--and is making--a major commitment of its effort and resources.

I am on record as believing that we still set the style and pace for the whole world in terms of graduate education. And, although quality variations at the college level are more extreme here than elsewhere in the developed world, where in general, there is more central control, on average we remain competitive. At the precollege level, however, we have fallen far behind our international competitors and friends both in quality and in number; our system has very serious difficulties. All of you are familiar with some of the dismal statistics--but they bear repetition.

The latest National Research Council study entitled "The State of School Science" shows that:

- Only one-third of the nation's high schools offer more than one year of mathematics or science.

- At least half of all U.S. high school graduates have taken no more than one year of biology, no other science and no mathematics beyong algebra.

- Only 105,000 U.S. high school students study any calculus at all while 5 million in the Soviet Union take two years of it. The Chinese situation is similar to the Soviet one.

- Japan now graduates annually five times as many engineers as does the U.S.

- Shortages of supplies and equipment in the schools have, in the last decade, cut, by more than half, the exposure to any form of laboratory experience by even those students who take science.

And there is more:

- At present, only 75% of those enrolled graduate from U.S. high schools; in some areas of the country this fraction drops to 55%. In contrast, 98% of all Soviet youth complete, successfully, a ten year-secondary school program generally agreed to be substantially more demanding than ours.

- Even worse, recent studies show that 20% of those who do graduate from U.S. high schools are illiterate and unable to function effectively in our society.

- And, across the board, average scores of high school seniors on Scholastic Aptitude Tests have continued to fall. The average score for which these tests were standardized is 500. In 1979 the national averages of those who took the tests were 427 and 467 for verbal and mathematical aptitude respectively; College Board estimates suggest that if all 3 million U.S. high school seniors had been tested the results would have been 368 and 402 respectively. Most serious of all, and contrary to popular belief, the fraction of those scoring in excess of 600 on these tests is now also decreasing although for many years it had remained essentially constant.

This is an unhappy litany and not one worthy of this nation.

Let me then focus on mathematics and science. There are two major inter-related questions here. First, we have the urgent problem of developing scientific literacy on the part of citizenry. Over 80% of our citizens receive their last exposure, if any, to mathematics and science during their high school years. In a society, such as ours, of growing technological sophistication where the questions of consequence increasingly have scientific and technological aspects, if our public cannot at least appreciate the nature of the issues, quite apart from contributing to their resolution, they inevitably will tend to become alienated from society. This is a trend that no nation can long endure.

From a more parochial point, to which I shall return below, increased public scientific literacy is a necessary--if far from sufficient--condition for the development of the new constituency for science and technology that I see as essential.

That the term "creationist science" and what it implies can be taken seriously by so many people is perhaps the most damning indictment we currently have of our failure in science education. If our lawmakers, school superintendents, publishers, and citizens understood the nature of scientific inquiry and evidence and the kind of knowledge that flows from it; if, in short, they had had education in science appropriate to our time, then "creationist science" would be seen not to be science, whatever else it might mean--and there would be less danger of the sort our schools now face. Although current engagement is taking place in biology, let there be no misunderstanding--the attacks represented by "creationist science" are drawn from the same narrow intellectual base which powered 19th century assaults on science in general. Now, as then, the "creationist scientists," despite their apparent new garb, are attempting to stifle rational investigation, freedom of research and teaching and wish to reshape the basic fabric of education. Make no mistake, this is not a matter which can be dismissed lightly or laughed away.

Second, we have the question of providing science and mathematics in high schools of such character that they will attract a greater fraction of the Nation's most able youth into mathematics, science and engineering careers as well as provide them with the educational foundations appropriate to such careers.

These two questions of scientific literacy and of preprofessional education are quite distinct and must be recognized as such. Programs and changes designed to answer one may well be inappropriate for the other.

We must avoid the common trap of assuming that since U.S. scientists continue to receive the lion's share of Nobel Prizes in science, our educational enterprise cannot be all that bad. Prizes won now reflect research of 10 to 20 years ago and education of perhaps 20 to 30 years ago.

What can we do to turn around a system that involves over 25,000 schools, some 16 million students, over 1 million teachers and administrators and that each year now accounts for about 95 billion tax dollars? Perhaps little, but we must at least try--we must not expect miracles--and we must begin now. We must return to objective standards of performance and learning; we must maintain discipline so students can study and learn; we must remove raw violence from the classroom; and we must stop social experiments carried out at the expense of our children. For the good of our Nation we must begin to spend at least as much time and effort on the most able 10% of our students as we do on the 10% least able.

And most of all, we must give all of our students some knowledge and appreciation of all cultures. It is shocking to find that high school graduates know no mathematics or science; it is even more shocking to find a great many who have never read a novel or who are unable to write a coherent paragraph--sometimes because they have never been expected to!

We currently are experienceing a serious shortage of mathematicians, natural scientists and engineers in this country. It will inevitably worsen in the mid 80's since educational time constants prevent any quick fix.

Let me illustrate with a few concrete numbers assembled by Lee Grodzins for physics and astronomy; very similar statistics can be assembled for chemistry and engineering.

- The number of Ph.D's awarded in 1980, in physics and astronomy was 985--almost identical to the number in 1965 and only 57% of the 1740 awarded in 1971.

- The number of Ph.D's employed in the U.S who actually practice physics in 1977 was 18,000, virtually the same as in 1968 and down by 10% from the 1970 peak period.

- During the 1979-1980 academic year the number of foreign students enrolled in U.S. colleges and universities rose to a record level of 286,430--more than 8 times the number enrolled in 1954-55. Some 55% of the present foreign students are enrolled in scientific and technical fields; almost half of them are in engineering.

- Of the 2379 Ph.D's awarded in engineering in 1980, 49% were to foreign citizens. The fraction of foreign citizens receiving Ph.D degrees in physics has increased from 14.3% in the early 1960's to 24.4% in 1980 (and to an extrapolated 28-30% in the late 1980's; comparable comparable figures for chemistry are 12.1%, 21.% and 23-27% respectively; and for engineering 21.4%, 49% and 50-60% respectively).

At a time when we are just beginning to see an increase (11.5% in the number of graduates in 1980--the first increase since 1970) in the fraction of U.S. high school graduates entering and graduating from engineering schools we see a much stronger exodus of engineering faculty to the private sector. Similar trends are apparent in college and university mathematics and natural science departments--and in high school science departments.

With industrial salaries twice those in higher education and often three times those now being offered in high schools, we cannot be surprised to see them accepted. Nor can we question the private sector need for such persons. It has never been greater.

But as I have emphasized elsewhere, we really are eating our seed corn. Information on the unfolding extent of this depletion has been acquired in recent surveys by the National Science Teachers Association. They found that drastically fewer persons are now being prepared to teach math and science compared with ten years ago: a 64% decline for science teachers and a 78% decline for math teachers. Of those who prepare to teach science and math, the number who actually seek teaching jobs has declined even more; a decline over the past ten year of 74% for science and an decline of 80% for math. These findings --as a leading indicator of what lies ahead--have stunned many observers.

The time has come when the academic and private sectors must recognize and address more directly their interdependence. I shall return to this below but on a more positive note, I am happy to report that there have been recent encouraging developments.

- As group of Pittsburgh companies has set up a $750,000 fund to provide, among other things, computer services to the city's junior and senior high schools.

- Exxon has made a grant of $150,000 to Florida State University specifically to slow the brain drain of young faculty to industry and a substantially larger one to MIT for the same purpose.

- Phillips Petroleum has made a contribution of 6 million dollars, to be administered by AAAS, and used for improving secondary school education in mathematics.

- IBM reports that over the past five years it has contributed 23 million dollars for programs, faculty and equipment in science, mathematics and engineering departments across the Nation.

- Companies such as Hewlett-Packard and Intel have developed programs that annually contribute millions of dollars of equipment to colleges and universities throughout the nation, and

- Johnson and Johnson has taken over sponsorship of the NOVA science program on public television.

We can hope that these corporate initiatives will be widely recognized and paralleled.

Turning to another area, faced with very real personnel shortages we still do a miserable job of attracting women and minority group members into mathematics, science and engineering. Current statistics suggest that we are making progress toward increasing the participation of women in science and engineering--although not in mathematics. Doctoral awards to women in science and engineering have increased from 7% in 1965 to 23% in 1980 but women still have higher unemployment rates and lower salaries than men in all fields.

The situation regarding minorities is much bleaker and indeed we appear to have regressed. The number in science, mathematics and engineering is significantly lower than it was 10 years ago. In physical sciences, life sciences and mathematics, for example, the fraction of total Ph.D's awarded to Blacks has decreased by almost a factor of 2--from 2.9% in 1973 to 1.71% in 1980. In 1980, American Indians, Blacks, Puerto Ricans and Mexican Americans received 0.3%, 2.1% and 0.2% of the doctorates, respectively, in science and engineering; of these well over 50% are in the social sciences.

We are wasting talent here for which the Nation has urgent need. I am convinced, however, that the heart of the problem remains in the secondary school and that we cannot realistically expect much improvement elsewhere until we can make substantial changes at this level.

I have already mentioned the serious problem regarding teaching and laboratory instrumentation at the high school level. The college and university situation, is if anything, worse and is rapidly approaching a national scandal. In field after field, supposedly representing high technology frontiers, we are educating students with instrumentation frequently twenty and more years old--instrumentation of another age and generation. Little wonder that we all too often fail to attract or hold our students' interest!

This instrumentation question is serious for all physical sciences; it is particularly serious in engineering where graduates of even our best known engineering schools are confronted with entirely new and unfamiliar instrumentation on their first jobs and require substantial additional private sector investments in retraining and familiarization.

One of my major worries, in the interface with education, however, is that we may have learned too little from recent history. In 1962, the Gilliland Panel of PSAC, responding to a widespread perception of impending shortages of personnel for the Nation's space and military programs recommended a crash program of support for students and for universities. Universities responded enthusiastically--in retrospect, much too enthusiastically--so that the 1970 manpower goals were achieved in 1967 and, not surprisingly, the crash program was terminated. Such abrupt changes--both positive and negative--applied to any tightly-coupled system having several similar time constants, will, as any engineer or physicist will recognize immediatley, cause the system to oscillate. As oscillate it has. The large number of students educated in 1960's via the crash program had difficulties finding employment once the program was terminated. Media reports of these difficulties--frequenlty exaggerated--influenced a new generation of students away from science and engineering with our present shortage as a consequence.

Obviously this is an oversimplified scenario--but it emphasizes a characteristic of our sytem that has caused untold wastage, hardship and heartache among some of our most talented young people, those for whom the country has the greatest need.

Why am I worried? Because I sense pressures for measures that can begin a new oscillatory cycle in response to our current shortages of trained manpower. Obviously we must take steps to meet and correct these shortages; new support for people, programs and instrumentation is badly needed but we should not mount a new crash program designed to produce large, short-term outputs. Rather, we should concentrate on long-term improvements in education which will attract adequate number of our best and brightest.

Finally, as a vital policy question, I think that is is terribly important for us to bear down on the question of federal support of science education. I think the Congress acted wisely when it amended the NSF organic act in 1972 to stipulate that the NSF should "initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels . . ." (emphasis added).

It is not very realistic to expect each State to "reinvent the scientific and technological wheel." Also, budget pressures will operate against them staying current with the latest advances on an individual basis. I think it is important to note that the NSF has never "dictated" to schools what they should teach; rather their purpose has been to serve as a resource for the States and individual school districts to use material as they see fit in local educational programs.

On the other hand, I do not wish to be in the position of defending each and every element of previous NSF science education programs. And given the Administration's agreement that there are serious problems and given its expressed willingness to consider various alternatives, it would seem that an urgent priority for you would be to seek the forging of an acceptable science and engineering education policy--not only for the NSF but also for the Federal Government.

Two specific areas are of special concern to me. First, time and time again as I've talked with secondary school science and mathematics teachers in different parts of the country, I have been impressed by the degree to which they have relied on NSF-supported summer programs to keep them in touch with their professional fields. These teachers have expressed their deep feelings of dismay and sense of loss at the demise of these programs following cutbacks in NSF support. These programs are particularly important for our very best secondary school teachers. They are important to the Nation. And I believe that they should not only be reestablished, but strengthened. They are an immensely cost effective investment in our youth.

Second, I have long regretted that for many reasons, the programs for pre- and post-doctoral fellowships based on competitive excellence have dwindled as other programs fostering greater equity of opportunity have grown. Important and essential as these latter continue to be, we should not forget that to a remarkably disproportionate degree our future rests in the hands of our most able youth in all parts of the country and from all elements of our society.

Programs for competitive fellowships have identified, encouraged, and supported such persons, particularly in areas of perceived national need. These programs seem to be one of our most obvious investments. I have been encouraged by the support that has been made available in this area by NSF. But the support levels have been far from commensurate with the national importance of these programs or with the seriousness of the problems we face in attracting and retaining adequate numbers of the very best young people in science, mathematics and engineering. Major expansion of existing programs here would also, I believe, Mr. Chairman, represent an exceedingly cost effective investment.

Impact on the Scientific and Technical Communities of Uncertainty and Budget Revisions and Stability in the R&D Planning and Budget Process

Turning now to the final questions you asked, I have chosen to combine them. I will begin with a clearly obvious statement: science and technology are inevitably conditioned and shaped by the society in which they are imbedded. Therefore, to expect immunity from the forces and influences--and especially political forces and influences--at work in our society is not very realistic. Nor do I believe that responsible scientists and engineers expect such immunity.

And if you ask me about Presidents changing budgets, I can't say that I like the uncertainty all that much; however, I also have to acknowledge it is a way of life. Presidents Nixon, Ford, Carter were not too inclined to keep their predecessors budgets--and even made changes in their own.

Perhaps I'm being too philosophical about this, but changes in Administrations and political views inevitably bring uncertainty, confusion and new people. Let me, however, make certain general remarks about uncertainty and variability in the support of scientific research. Research groups, particularly the most productive ones, are extraordinarily fragile; their members have complementary chemistries and interests and once disbanded they can never be reassembled. Consequently, there's always a tendency in times of uncertainty to protect the research group's existence--in hope of better days--and often without due consideration of longer range costs.

What are some of these costs? Let me give only a few examples. Development of new instrumentation, new devices, and new techniques is frequently an early casualty and an extraordinarily costly one. This is because such development really is our gateway to new frontiers and to a productive future. The high risk study with low success probability and with the potential of revolutionary consequences, if it should pay off, is another early casualty. Uncertainty breeds short time horizons, limited expectations, and a tendency to "hunker down." It also kills enthusiasm. In short, over any extended period, uncertainty is inimical to the very fabric and structure of research and it strikes in deadliest fashion against our investment in the Nation's long-range future.

Most of all, this is true in terms of human resources: We already, as I have noted, face serious shortages of trained personnel in many fields of science and engineering. But nothing is more discouraging to promising young minds than the spectre of continuing uncertainty in our research opportunities and career possibilities. Such uncertainty makes coherent planning particularly difficult--if not indeed impossible--for our youngest, brightest, most important resources. They are all too frequently lost. In today's science and technology this is a loss that we as a Nation can ill afford.

And there is a domino effect: Discouraged and disenchanted young scholars send a powerful message back to the secondary schools--particularly to the most able students--and many of the students who might otherwise have entered the important areas in question are also lost.

There is another aspect of change that bears emphasis. After a period of growth, any field can more readily accommodate leveling or even declining support for some limited time. This is frequently a time of self-selection in which some of the least excellent activities are weeded out; it is a time of consolidation in which the fruits of the growth period are brought into better perspective and integrated into the broader world of science and technology. Currently, however, if I can take physical sciences and mathematics--the areas with which I happen to be most familiar--as examples, we find ourselves at the end of more than a decade of almost level dollar funding, a decade where inflation has taken a heavy toll on our capacity to do research and to train new scholars. A brutal weeding process has already occurred and further reductions are not pruning away the less than excellent. By any measure they are cutting directly into our national excellence itself. This too, we simply cannot allow to happen.

Let me deal with a last facet of stability and change. Over the past four decades and more we have evolved a complex mix of university facilities, national laboratories and industrial research organizations that has served us well. Some of these have more effective internal renewal mechanisms than others and have been more able to respond to changes in mission objectives and public expectations. I believe that lacking adequate renewal and redirection mechanisms, some areas of our national research capacity are seriously underutilized, at a time when we are very much in need of more, and better, research.

We have never found it necessary to rationalize our present mix of research facilities and institutions; they grew in response to local and immediate needs. When resources are in critical supply, when new and urgent demands for both research and researchers are being made on the system, however, I believe that the time has come for us to undertake this rationalization, to reexamine our national research enterprise in the light of present and future needs. Frank Press, President of the National Academy of Sciences and Science Adviser in the Carter Administration commented on this point a few months ago:

> "...(the scientific community) may also direct its attention inward, offering to re-examine the national research enterprise--including academic research, national laboratories, and industrial research--to learn whether new institutional relationships and other structural changes can preserve our scientific strengths in a period of financial stringency. All sections of the scientific community must be prepared to set aside the shibboleths of the past and perhaps propose new modes of research just as effective yet less costly..."

While acknowledging the need for continuing renewal and supporting the call for a reexamination of our scientific and technological enterprise, I cannot emphasize too strongly what may appear to be a rather conflicting cautionary note. This note focuses on all changes that may emerge: changes in our desired rates of manpower production; changes in our mix of scientific institutions--or indeed of science; changes in our support levels; and changes in our support institutions.

There are natural time constants associated with the enterprise and its distinct elements. A Ph.D. program requires 4-5 years; a major new facility may require 5-10 years for its realization; a new experiment may require several years from conception to completion. Changes--either up or down--that do not recognize these time constants can be a waste of both resources and talent in addition to being actually counterproductive. I would urge, Mr. Chairman, that whatever changes may emerge from your considerations and those of the Administration be made gradually so that the systems involved can adjust with minimum damage.

For better or worse, science and scientists are committed and involved with the government; they are integral to the major missions of virtually every agency. The major issue, today, is not whether to become involved as it was 50 years ago, but how best can science be employed for the well-being and security of our nation.

Science and Society and Stresses Other Than Budgets

As I observed earlier, science and technology are inevitably conditioned by the society in which they are embedded. There has been much talk in recent years in this country of rampant anti-science sentiment. I do not believe that this exists but, on the other hand, there _is_ widespread anti-technology sentiment and, unfortunately, a very large fraction of our public is unable to distinguish between the two.

I have already touched on the question of improving science teaching, and thus science literacy, in forthcoming high school graduating classes. But this is clearly not enough. Our present adult population can no longer be directly affected by changes in our high school systems.

There is evidence to suggest that a very significant fraction of these adults have a real hunger for accessible, authoritative information about science and technology. There has been an explosion of new popular magazines--Science 82, Discover, Next, Science Quest, Science Digest, Technology, and many other directed to this market; the success of the NOVA and COSMOS television series provides additional evidence.

The science and technology community in this country has a very real responsibility to respond to this public interest, partly in accounting for support received, partly because its members _want_ to talk and write about what they are doing, and partly because it is in the best interests of the science and technology community to foster public awareness of science and technology.

This raises, again, Bob Giamo's question of the U.S. constituency for science and technology. Although rarely stated overtly, for several decades following World Warr I, public support for science was tied, consciously or unconsciously, to national security and defense. In part, this was a holdover from the war years themselves. During the late 1960's, in the shadows of the Vietnam conflict and with burgeoning anti-technology sentiment, this linkage became increasingly precarious and suspect.

On November 7, 1973, in a television address to the Nation, President Nixon attempted to shift major support for science and technology to the quest for energy self-sufficiency. He called for energy independence by 1980 via a major national commitment, "in the spirit of Apollo, with the determination of the Manhattan Project." As part of this commitment he called for the creation of an Energy Research and Development Administration (ERDA).

As we all know, ERDA came and has gone; its successor agency, the Department of Energy came and now it, too, may be going--although our energy problems certainly have not gone. Energy, it seems, is not the star to which our science and technology wagon should be hitched.

I am convinced that the ultimate answer must lie in an informed, interested public prepared to understand--at least in outline--and support science and technology on their own merits and in recognition of the vital role they play in almost all aspects of contemporary life--energy, health care, environment, commerce, trade, national security and international affairs, to list only a few.

If this is to happen, it requires a major commitment by members of the science and technology community to improving adult scientific literacy. It is not enough to leave the task to the tiny group of professional science writers, able as many of them are, to Carl Sagan and others who have learned to use television in ways captivating to a general public. Improving public understanding of science is one of the stated goals of AAAS, and one toward which we are making significant progress, but we have not, as yet, found the necessary mechanisms to mobilize all our members as catalysts in this important mission.

In working toward this goal of better public understanding of science and technology, it is well to bear in mind that a much deeper question is involved. Can science and technology be permitted to go their own way--to follow their internal logic--in isolation from the societies in which they are embedded, or must some system of independent value judgments be made first by those societies forming a framework within science and technology must function?

We are closer to this situation than you may think. Remember that the Cambridge, Massachusetts, City Council, by democratic vote, prevented any research on recombinant DNA at Harvard for almost a year--although there is substantial question as to whether any member of that Council had any real idea of what the vote implied--or that by voting as the Council did it might well delay a possible cure for cancer much more probably than unleash any danger whatever on the citizens of Cambridge. But, increasingly, the public is demanding to be heard in decisions which even now are entirely internal to science and technology.

A related question, increasingly being posed, is whether scientists have special responsibilities by virtue of being scientists. After all, lawyers are officers of the court, physicians and engineers must adhere to standards set by their peers. Are there collisions between such notions of responsibility and the traditional notions of scientific freedom?

I find it convenient here to return to my earlier dichotomy between natural philosophy and mastery of nature. In the former, the pursuit of knowledge, because I believe deeply that none of us are wise enough to even guess the future uses for new knowledge. I believe equally deeply that there should be no artificial limitations or boundaries. Ultimately, I cannot believe that ignorance is ever preferable to understanding.

But at the same time, as in the examples I have just listed, when we turn to the utilization of knowledge, either old or new, I am convinced that there must be adherence to generally accepted standards and limitations. But I am not convinced that scientists and engineers are wise enough to establish these standards and limitations in splendid isolation and by peer agreement. Input is essential from those outside our guilds.

Let me consider only three examples from among the many pressing problems--facing us nationally and internationally today--that may illustrate this point.

- Human population growth is the most deadly spectre looming over us today, and its control one of our greatest challenges. In 1950, we had 2.5 billion people on this small planet; in 1981, we have 4 billion, and in 1990 our best estimates suggest 6 billion. This exponential growth--but our public is programmed to think in only linear terms. Crucial human values are involved here; in the last analysis, we are balancing freedom to reproduce against the quality of subsequent life--if not, indeed, against that life, itself--in those areas of the world where starvation is a constant threat. The technology is in hand--although it needs improvement--to turn off human fertility unless an antidote is taken. I see no other solution ahead, but I also see enormous social and political problems in implementing any such solution.

- I have mentioned the energy problem as crucial. Here, again, we know the technology that would give us essentially unlimited energy--but none of the current technologies, coal, nuclear, solar, will provide the energy necessary for maintenance of anything beyond a rural life-style for much of the planet unless present societal values can be changed to permit their more effective implementation.

- Health care delivery is another area of growing stress. With rapidly improving technology, as long as we are prepared to pay the cost, we can keep people--who only a few years ago would have died early--alive almost for their full, and growing, span of years. Dialysis, required regularly after kidney failure, is a case in point. Right now, we in the U.S. have the technology. Right now, something like 100,000 Americans are on regular dialysis--and right now, we are paying about $2.5 billion a year to support this program alone. Where do we draw the line? As things now stand, we will, in the near future, find ourselves forced to tell someone, "We are sorry but we can't afford to keep you alive, even though we do have the technology." Who will make that decision? And on what basis? How do we decide who gets the benefits of advancing medical technology?

  Genetic engineering raises other spectres. If and when it becomes possible to influence significantly the characteristics of ones offspring, for example, should the parents have complete freedom to make whatever changes may appeal to them? If not, what are the limits? And who decides? And on what bases?

In all of these examples--and there are many more like them--examples that are normally presented as problems for science and technology--much of the technology and science is already at hand. What we lack is agreement on the underlying values and priorities--and adequate knowledge of the social, behavioral, and economic consequences. All of us, humanists, social scientists, natural scientists, are in these problems together. And the time when we face up to this and get to work is long overdue.

Humanists, deeply involved in the study of mankind, are well acquainted with the seamier sides of our nature, with our shortcomings and failures. In consequence, if I may be permitted a huge oversimplification, they tend to be pessimists. Social scientists tend to be pragmatists, to take the world as it comes and not get too excited about it. Recently, I took a group of distinguished economists to lunch because I wanted an answer to the deceptively simple question, "What is our economy going to do?" The answer--entirely unanimous--was, "How the hell should we know?--It's never behaved this way before!"

Natural scientists tend to be optimists; they are inclined to be impatient to see if something can be done; and inclined to believe that it can, until proved otherwise.

These are all caricatures, but there is truth in each of them. What we badly need is a fusion of all of them. Not only must we work together--and in so doing learn to actually communicate with one another--but also we must be mutually supportive. In this past year, it has been of the greatest importance that natural scientists and humanists were willing to speak out in defense of their social science colleagues faced with precipitous and unprecedented funding cuts. There is a unity to all science and technology that we will destroy or let perish only at great peril.

And at a time of growing shortages of scientists and engineers, we cannot be comfortable with the fact that we have failed so miserably to bring more women and more minority group members into the forefront of our activities. Our goal must be that of supporting excellence wherever we find it; the obverse is that in a time of limited resources and high competition we must never be satisfied with less than excellence.

Let me in conclusion, Mr. Chairman, thank you and your colleagues on the Committee, on behalf of the AAAS, for this opportunity to share with you a number of my concerns, as we attempt to forge a new partnership for the most effective growth and use of U.S. science and technology in a time of budget stress.

Appendix

CRITERIA FOR PROGRAM EMPHASES

Three sets of criteria emerged from our discussions and were refined through application to program elements in the various subfields.

Questions used to determine *intrinsic merit* were the following:

1. To what extent is the field ripe for exploration?

2. To what extent does the field address itself to truly significant scientific questions that, if answered, offer substantial promise of opening new areas of science and new scientific questions for investigation?

3. (a) To what extent does the field have the potential of discovering new fundamental laws of nature or of major extension of the range of validity of known laws?

(b) To what extent does the field have the potential of discovering or developing broad generalizations of a fundamental nature that can provide a solid foundation for attack on broad areas of science?

4. To what extent does the field attract the most able members of the physics community at both professional and student levels?

To assess *extrinsic merit*, we asked:

5. To what extent does the field contribute to progress in other scientific disciplines through transfer of its concepts or instrumentation?

6. To what extent does the field, by drawing on adjacent areas of science for concepts, technologies, and approaches, provide a stimulus for their enrichment?

7. To what extent does the field contribute to the development of technology?

8. To what extent does the field contribute to engineering, medicine, or applied science and to the training of professionals in these fields?

9. To what extent does the field contribute directly to the solution of major societal problems and to the realization of societal goals?

10. To what extent does the field have immediate applications?

11. To what extent does the field contribute to national defense?

12. To what extent does activity in the field contribute to national prestige and to international cooperation?

13. To what extent does activity in the field have a direct impact on broad public education objectives?

Taken from Physics in Perspective, Volume 1. Physics Survey Committee, National Research Council. National Academy of Sciences: Washington, D. C., 1972. Chapter 5, pp. 400-401.

Questions to establish *structural* criteria were:

14. (a) To what extent is major new instrumentation required for progress in the field?

(b) To what extent is support of the field, beyond the current level, urgently required to maintain viability or to obtain a proper scientific return on major capital investments?

15. To what extent have the resources in the field been utilized effectively?

16. To what extent is the skilled and dedicated manpower necessary for the proposed programs available in the field?

17. To what extent is there a balance between the present and envisaged demand for persons trained in the field and the current rate of production of such manpower?

18. To what extent is maintenance of the field essential to the continued health of the scientific discipline of which it is a part?

Mr. **Fuqua**. Thank you very much, Dr. Bromley, for a very fine statement. You may remain at the table if you like.

Our next witness will be Dr. Robert W. Parry, president of the American Chemical Society. We are very happy to have you join us today.

STATEMENTS OF DR. ROBERT W. PARRY, PRESIDENT, AMERICAN CHEMICAL SOCIETY AND PROFESSOR OF CHEMISTRY, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH; AND DR. FRED BASOLO, MORRISON PROFESSOR OF CHEMISTRY AT NORTHWESTERN UNIVERSITY, EVANSTON, ILL; AND PRESIDENT-ELECT OF THE AMERICAN CHEMICAL SOCIETY

Dr. **Parry**. Thank you, Mr. Chairman.

The **Chairman**. Also, if you wish to make your statement part of the record and summarize, you may.

Dr. **Parry**. This will be a summary of the statement submitted for the record.

Mr. Chairman, members of the committee, the American Chemical Society welcomes this opportunity to present views on U.S. Science and Technology Under Budget Stress.

We hope that the society's comments will be of value in your deliberations. I appear before you today with the authorization of the board of directors of the American Chemical Society. Accompanying me is Dr. Fred Basolo, Morrison professor of chemistry at Northwestern University, and president-elect of the American Chemical Society.

In earlier testimonies given to this committee by Drs. Keyworth, Press, Stever, and Bromley, the case was made for science in general. While many features unite the various scientific disciplines, these disciplines also differ in their organizational patterns and in their top-priority research needs.

For example, in high-energy physics an accelerator may hold the key to progress; in astronomy, a large telescope may be central to future advancement. On the other hand, progress in chemistry arises from a significant number of small, but well-equipped laboratories.

Today, my remarks will focus on the research needs in chemical science. You may recognize many of the points in Dr. Bromley's testimony in my own. This was not planned. But, our analysis of many of these issues turns out to be very similar.

What drives the technological machine which serves society so well? Most scientific disciplines, ranging from molecular biology to astronomy, make use of chemistry. It is central to a large part of the Nation's health effort including the development of new therapeutic agents.

It is central to a very large segment of our industrial development. Let me give you an example. In the history of crude oil, conversion of crude oil to gasoline, an active catalyst was found which increased the gasoline yield dramatically. It is estimated 200 million barrels of crude oil are saved each year as a result of this process.

The potential for further discovery and technological advancement in the chemical sciences is vast. Chemistry is poised as never before to enter a new period of fruitful inquiry because of advances in theory, discoveries in chemical synthesis, and the advent of new classes of instrumentation.

What drives this technological machine which serves society so well? Every technological advance had its origin in or was heavily dependent upon ideas and experience emanating from basic research laboratories.

One then wonders who has responsibility for the support of this basic research effort. Drs. Keyworth, Press, and Stever, and also Dr. Bromley, have all agreed the Federal Government must play a central role in maintaining America's basic research. This is also the view of the American Chemical Society.

According to the NSF series, Federal Funds for R. & D., total Federal funding for basic research in chemistry was $290 million in 1981. The Department of Energy and National Science Foundation provide half of all the Federal funds for basic chemical research.

While NSF supports only about 10 percent of the total basic work in chemistry nationwide, it funds 33 percent of that done in universities. What other sources of support exist for basic research in chemistry? This is of particular concern while we are talking about what other alternatives we might have.

A few private foundations with limited resources are active in funding this research. For example, following World War II, resources from six major petroleum companies were used to establish the petroleum research fund, a charitable scientific and educational trust.

The American Chemical Society administers the distribution of income from this trust fund to support advanced scientific education and fundamental research in the petroleum field. I might point out that most of these funds support chemical research at universities.

In 1982, about $7 million will be distributed. In recent years, the society has been exploring the possibility of creating another private fund patterned after the petroleum research fund for the support of basic chemical research. This point I think is very significant.

To date, results have been very discouraging; industrial leaders generally have not been supportive of such an effort.

Still, the chemical industry has a long history of supporting basic chemical research in universities through special grants, fellowships, or cooperative research projects.

We note, however, the extent of such support is relatively small. According to a survey conducted by the newly formed Council for Chemical Research, chemistry departments received an estimated $14 million, and chemical engineering departments $12 million. This level of support for chemistry, when added to the $7 million from the petroleum research fund, is small compared to Federal expenditures of $290 million for basic chemical research, over half of which goes into academic research.

In our judgment, the responsibility for the support of basic research in chemistry lies clearly with the Federal Government. There absolutely is no indication that the industrial community can or will shoulder any significant increased proportion of the burden for funding basic chemical research in universities.

A funding policy based on such an assumption is unrealistic. Is it too early to assess the impact on chemistry of the R. & D. tax credit provisions and the increased deduction for instrument donations enacted last year as part of the Economic Recovery Tax Act. It is hoped that the credit truly is an additional incentive to industry to increase their support for research overall.

The American Chemical Society agrees with Drs. Press, Stever, and Keyworth that when resources are limited, a sound approach is to fund only the best proposals. Merit of each individual proposal should be the basis of the funding decision.

In recent years, peer review has been the basis for proposal selection. In our opinion, the system has worked well. The quality of basic research supported by most agencies has been very high.

At present, the NSF chemistry division is funding only one out of five proposals it receives from first-time applicants. To objectively identify the best proposal out of these five without expecting some differences in evaluation is unrealistic. No known evaluation system can meet such a challenge 100 percent of the time because a component of subjective value judgment is involved in proposal evaluation.

There is currently little evidence to suggest that additional savings can be gained without scientific loss. This is supported by the findings of seven specially appointed panels that reviewed the operation of the chemistry division at NSF. Without exception, the panels praised the way the chemistry division insures that only high-quality research is funded.

Another effort to evaluate Federal basic research programs is currently underway. A panel has just completed the evaluation of the basic energy science programs of the Department of Energy. Dr. Bromley and I both serve on that panel.

As a member of the panel I can say that of the programs examined, we found very little evidence of poor or even second-rate science.

On the contrary, there is evidence that the current limited basic research budgets are seriously hampering desired scientific development. For example, the competitive nature of the selection process is having a strong negative impact on young investigators who are tomorrow's scientists.

Those who are new to the system, who are just developing a reputation, and whose record of accomplishments is limited, are having a terrible time obtaining funding. In fact, our observations lead us to believe that the country's basic research effort is underfunded and real benefits would flow in the years ahead from an increase in the funding available for this enterprise.

Increased DOD support of basic research in universities and industrial laboratories would help remedy some of this underfunding situation.

Selecting basic research projects which will pay off is a tricky business. In fact, it would be far easier to select the Super Bowl winner at the beginning of the football season. In our case, we understand the nature of the contest, but the schedule is mostly undefined; we do not know ahead of time what we might run into. Furthermore, our strategy and execution are hampered when the rules are changed without notice.

So, far, our best course of action seems to be to give a large number of bright, innovative investigators a chance to ask mature questions in many areas. From the answers, we expect to realize progress. We agree with Drs. Stever and Press that the country would profit greatly from an increased effort in basic research, both industrial and academic.

It is important that the Federal Government view support of basic research in terms of supporting the research system in its totality. Three other issues deserve comment in this regard. They are: (1) continuity of research support; (2) condition of instrumentation in our university laboratories; and (3) manpower problems which we see for the future of chemistry and America.

At present, one of the most serious problems in the administration of the country's basic research effort at all levels relates to sudden budget cuts and withdrawal of funds. The American Chemical Society enters a strong appeal for increased stability in the funding process. The Nation should make a long-term commitment consistent with its long-term scientific and economic goals.

Lacking definite suggestions for long-term solutions to the stability-of-funding problem, the society joins those in the scientific community and the Congress who urge that the problem be carefully examined. The American Chemical Society would welcome the opportunity to explore with appropriate Government officials possible solutions to this problem.

One additional problem which concerns the American Chemical Society is the reported inability of U.S. colleges and universities to provide the instruments and equipment necessary for student instruction and the performance of research by faculty and staff.

The consequences can be severe when new instrumentation or equipment cannot be obtained, or when obtained, cannot be maintained properly. A number of surveys, including one by the ACS, are underway in the area of scientific instrumentation. Attention will be given in the ACS survey to the wisdom of using funds originally intended for research projects to provide research instrumentation.

All these issues, especially funding, warn of a problem we believe lies ahead. Will the United States have an adequate number of chemical professionals to operate the chemical enterprise in the next 5 years? We believe there is cause for concern. Already there is a very serious shortage of Ph. D. analytical chemists and chemical engineers. This problem is so severe that a chemical industry panel is investigating our options as a profession. Survey data indicate that the shortage of professionals will get worse before it improves, and that it will soon involve all branches of chemistry, not just analytical chemistry and chemical engineering.

In 1970, the United States produced 2,235 Ph. D.'s in chemistry. That was our high watermark, 2,235; since then there has been a steady downturn. In 1980, the country produced 1,538 Ph. D.'s in chemistry. By way of comparison, 1,594 Ph. D. chemists graduated in 1966, so in 1980, we are below 1966. And the supply in 1966 was judged inadequate for the Nation's needs.

To further complicate our current problem, a sizable fraction, 22 percent, of the 1,538 Ph. D.'s produced in 1980 was composed of foreign nationals, most of whom will not be available for the U.S. labor force because of immigration laws.

Further, the number of U.S. citizens reaching the age of 18 will be declining over the next 10-year period from 4.2 million in 1980 to 3.3 million in 1990, and these are firm numbers. And the interest of high school graduates in science and mathematics is declining. We have good reasons to be concerned over these facts.

Up to the present time, our presentation has not addressed the question of possible savings in the R. & D. sector. We agree with Drs. Keyworth, Press, and Stever that applied research and development are principally an activity for the private sector and will be pursued by industry except in the special cases of defense, space, and nuclear technology. As Government moves out of applied research, development, and some demonstration activity, the funds liberated might profitably be used to support basic research.

Our testimony contains a summary which I will not read at this time. The contribution of the chemical sciences to the economic growth and to an improved standard of living in the United States in the past decades is well documented. The society appreciates this opportunity to urge that the knowledge base which has made this progress possible be maintained in a healthy condition by appropriate funding of scientific research.

Thank you for this opportunity to appear before you.

[The prepared statement of Robert Parry follows:]

Prepared Statement of Dr. Robert W. Parry, President, American Chemical Society

Mr. Chairman and members of the House Committee on Science and Technology, the American Chemical Society welcomes this opportunity to present its views on U.S. science and technology under budget stress. We hope that the Society's comments will be of value in your deliberations. I appear before you today with the authorization of the Board of Directors of the American Chemical Society. Accompanying me is Dr. Fred Basolo, Morrison Professor of Chemistry at Northwestern University, and President-Elect of the American Chemical Society.

In earlier testimonies given to this Committee by Drs. Keyworth, Press, Stever, and Bromley, the case was made for science in general. While many features unite the various scientific disciplines, these disciplines also differ in their organizational patterns and in their top-priority research needs. For example, in high-energy physics an accelerator may hold the key to progress; in astronomy, a large telescope may be central to future advancement. On the other hand, progress in chemistry arises from a significant number of small, but well-equipped laboratories. Today, my remarks will focus on the research needs in chemical science.

Our review of testimony given by Drs. Keyworth, Press, Stever, and Bromley has indicated a number of areas of agreement. First, all have commented positively on the social benefits of research. In this context, contributions made by chemistry to our national progress are most impressive. Everything in our physical world is made of material that lends itself to transformation, substitution, and preservation. These activities are carried out through chemical science and technology. Most scientific disciplines, ranging from molecular biology to astronomy, make use of chemistry. A large number of industries practice chemistry in the manufacture of their products. The routine analytical sciences which support the nation's health efforts use chemistry. In particular, medical testing and monitoring of food quality rely on methodology and instrumentation developed by chemists. Even forensic investigations in police work depend on chemistry. Chemistry is now helping to identify and solve the problems associated with proper disposal of wastes of all types. Chemistry is truly the "central science."

Chemistry, as a technological area, is directly responsible for at least 6 percent of the gross national product. In addition, chemistry plays a supporting role in food production and a crucial role in our energy technology. These areas alone account for over 30 percent of the gross national product. The foregoing facts emphasize the importance and diversity of chemistry in our economy. Other specific examples are of interest. Basic research in photochemistry, physical chemistry, and solid state chemistry contributed to the development of the silicon integrated circuit and to the development of optical fibers. Both developments resulted in startling changes in the communication industry. In the history of crude oil refining, the discovery of a catalytic method for cracking petroleum to produce gasoline increased the gasoline yield to 80 percent, as compared to a 50-percent yield of the raw crude oil processed using previous methods. It is estimated that 200 million barrels of crude oil are saved each year through catalytic cracking.

The potential opportunities for further discovery and application in the chemical sciences are vast. Chemistry is poised as never before to enter a new period of fruitful inquiry because of advances in theory, discoveries in synthetic chemistry, and the advent of new classes of instrumentation.

Underlying many achievements promised for the future is our improved ability in chemical synthesis. We can now prepare molecules that had been thought too complicated to make just a few years ago. We can even make molecules that had been considered incapable of existence. Much more progress is to come. Major advances are foreseen in the design and synthesis of macromolecules for ever more demanding applications. For example, on the horizon we may see the ultimate in computer microminiaturization. The "molecular computer," as its name implies, will use molecules for information storage. These molecules are being designed with the help of synthetic and surface chemists. Switching may even be accomplished through rotation about a chemical bond. Other further goals include designing materials appropriate for the fabrication of artificial organs and for the delivery of drugs to target organs or to pathological cells.

What drives this technological machine which serves society so well? Every technological advance had its origin in or was heavily dependent upon ideas and experience emanating from basic research laboratories. One then wonders who has the responsibility for the support of this basic research effort? Drs. Keyworth, Press, Stever, and Bromley all agree that the federal government must play a central role in maintaining America's basic research, and that is also the view of the American Chemical Society.

According to the NSF series "Federal Funds for Research and Development," total federal funding of basic chemical research was $290 million in 1981. Six federal agencies are the major sources of funds for such research in chemistry: the National Science Foundation, Department of Energy, Department of Defense, Department of Agriculture, Environmental Protection Agency, and National Institutes of Health. DOE and NSF provide half of all the federal funds for basic chemical research. While basic research supported by mission agencies certainly adds to the store of chemical knowledge, that basic research is not likely to exploit opportunities which exist outside the missions of these agencies. Thus, the National Science Foundation's support of basic chemical research is extremely important to the advancement of the science on all fronts, because NSF tries to ensure that opportunities in basic research not explored by the mission agencies are met through NSF programs.

NSF can support the bold idea, the fresh intuition, and the out-of-fashion field from which may spring the next major research and technology endeavor. Support of NSF is probably one of our better long-term uses of federal resources. While the National Science Foundation accounts for only about 10 percent of the total basic work in chemistry nationwide, it funds 33 percent of all the university basic research in chemistry. Thus, the vitality of the research base residing in our academic institutions depends heavily upon NSF.

According to NSF statistics, in the 1970's support for basic chemical research from all sources, federal and non-federal, varied little in constant dollars. The federal share fluctuated around 40 percent while industry's share fluctuated around 50 percent. This later point deserves comment. Corporate research, even when labeled basic research, is almost always structured to the near-term needs of business, and looks for a return on investment in a reasonable time period. Thus, industrial research complements, but is certainly no substitute for federal efforts to advance the science of chemistry on all fronts.

What other sources of support exist for basic research in chemistry? A few private foundations with limited resources are active in funding this research. Following World War II, resources from six major petroleum companies were used to establish the Petroleum Research Fund, a charitable scientific and educational trust. The American Chemical Society administers the distribution of income from this trust fund to support advanced scientific education and fundamental research in the "petroleum field." A good portion of these funds supports chemistry research at universities. In 1982 about $7 million will be distributed. In recent years, the Society has been exploring the possibility of creating another private fund patterned after the Petroleum Research Fund for the support for basic chemical research. To date, results have been very discouraging; industrial leaders generally have not been supportive of such an effort.

The chemical industry has a long history of supporting basic chemical research in universities through special grants, fellowships, or cooperative research projects. We note, however, the extent of such support is relatively small. There is an effort afoot to improve the situation. The Council for Chemical Research was officially organized last year to encourage increased industry support of university research in chemistry and chemical engineering, and to expand overall interaction in other areas of common interest. The Council conducted a survey to determine the amount of money industry contributes to university departments, of chemistry and chemical engineering. The Council found that in 1980, chemistry departments received an estimated $14 million, and chemical engineering departments $12 million. This level of support for chemistry, when added to the $7 million from the Petroleum Research Fund, is small compared to federal expenditures of $290 million for basic chemical research, over half of which goes into academic research.

In our judgment the responsibility for the support of basic research in chemistry lies clearly with the federal government. There absolutely is no indication that the industrial community can or will shoulder any significant increased proportion of the burden for funding basic chemical research in universities. A funding policy based on such an assumption is unrealistic.

It is too early to assess the impact on chemistry of the R&D tax credit provisions and the increased deduction for instrument donations enacted last year as part of the Economic Recovery Tax Act. It is hoped that the credit truly is an additional incentive to industry to increase their support for research overall.

It does seem, however, that the incentive is not sufficiently attractive to cause the chemical industry to assume a level of support for basic research in universities that is significant compared to the current direct federal effort.

As to stimulating in-house R&D, Dr. Keyworth has stated that the Administration estimates American industry will increase its investment by $3 billion over the next five years, largely in the area of applied research and development. We hope this prediction is realized. The increase would substantially benefit the nation.

The funding pattern of the chemical industry's in-house R&D is even more promising. Traditionally, the chemicals and allied products industries have invested heavily in R&D. Most of these expenditures have been financed with the companies' internal funds. In other industries such as aerospace, the federal government paid for most of the R&D. The Chemical & Engineering News annual R&D budget survey of the largest basic chemical companies (January 18, 1982 issue) reveals an increase in R&D expenditures of 21 percent, from $1.85 billion in 1980 to $2.24 billion in 1981. A growth of 17 percent is expected from 1981 to 1982.

If we accept the premise that the federal government bears the major and almost exclusive responsibility for support of basic research in chemistry, and that science policy must work within the constraints of economic policy as outlined by Dr. Keyworth, we then must examine the nation's options for funding science. As Dr. Keyworth noted, science is central to our problem-solving ability. To quote him:

"Science is a critical factor in determining our ability and readiness to meet the problems of the unforeseeable future. No one can tell at this time what all the problems of our society will be. But we can be sure that many of them will be inextricably tied to science, and that our future problem-solving capability will depend on the depth and breath of our scientific knowledge, particularly upon the type of breakthrough that comes from basic research."

The American Chemical Society agrees with Drs. Press, Stever and Keyworth that when resources are limited, a sound approach is to fund only the best. Merit should be the watchword; merit of each individual proposal should be the basis of the funding decision. Imposing geographic or institutional constraints on agencies for awarding research grants is difficult to justify, particularly in tight budget years. In recent years peer review has been the basis for proposal selection. In our opinion the system has worked well. The quality of basic research supported by most agencies has been very high.

At present, the NSF Chemistry Division is funding only one out of five proposals it receives from first-time applicants. To objectively identify the best proposal among the top two out of these five proposals, without expecting some differences in evaluation, presents a challenge no known system can yet meet. A component of subjective value judgment is involved. There is currently little evidence that additional savings can be gained without scientific loss. This is supported by the findings of seven specially appointed panels that reviewed the operation of the Chemistry Division at NSF. Without exception, the panels praised the way the Chemistry Division ensures that only quality research is funded.

Another effort to evaluate federal basic research programs is underway. A panel has just completed the evaluation of the Basic Energy Science Programs of the Department of Energy. As a member of the panel, I can say that of the programs examined, we found very little evidence of poor or even second-rate science.

Since the ACS agrees that the scientific community has a responsibility to join with government to ensure the quality of the basic research to be supported, we would be happy to assist government agencies in the evaluation of chemistry programs. This job would not be an easy one. The data from the NSF and DOE evaluations mentioned previously suggest the no significant savings can be expected from increased screening among projects in the basic chemical research area.

On the contrary, there is evidence that the current limited basic research budgets are seriously hampering desired scientific development. For example, the competitive nature of the selection process is having a strong negative impact on young investigators who are tomorrow's professors. Those who are new to the system, who are just developing a reputation, and whose record of accomplishments is limited, are having a terrible time obtaining funding. In some cases, their inability to secure funds has been used as a basis for denying them tenure. Many are doing high quality work which could well lead to great scientific advances. The ACS believes that when young investigators lose funding, the country is the real loser. Also, many established investigators who have difficulty maintaining support for their research programs under the current highly competitive conditions are dropping out of the research enterprise. Their value to the system as researchers, and as teachers, is lost or reduced.

To summarize several points made so far: the American Chemical Society believes, along with Drs. Keyworth, Stever, and Press, the only top quality basic research should be supported. We note that recent reviews give NSF and the Basic Energy Sciences Section of the Department of Energy good marks for their selection of very high quality research projects. We stand ready to assist the federal government in further evaluation of the nation's basic research efforts, but as yet there is no evidence to suggest to us that poor quality research is being supported. In fact, our observations lead us to believe that the country's basic research effort is underfunded and real benefits would flow in the years ahead from an increase in the funding available for this enterprise. Increased DOD support of basic research in universities and industrial laboratories would help remedy some of this underfunding situation.

Selecting basic research projects which will "pay off" is a tricky business. In fact, it would be far easier to select the Super Bowl winner at the beginning of the football season. In our case we understand the nature of the contest, but the schedule is mostly undefined; we do not know ahead of time what we might run into. Furthermore, our strategy and execution are hampered when the rules are changed without notice. So far, our best course of action seems to be to give a large number of bright, innovative investigators a chance to ask questions about nature in many areas. From the answers, we expect to realize progress.

It is tempting to believe we can look at disciplines or segments of disciplines and see which areas will be fruitful, and which should be abandoned. Some people even believe they can suggest which questions should be asked. Science and scientists, however, have a poor track record here. Just before the turn of the century severaly very influential scientists indicated that all great discoveries in physics had been made. In their judgment the physics of the future would concentrate on defining known constants at a higher level of accuracy. A comparison of the world of 1880 and the world of 1980 would indicate how wrong they were. Imagination coupled with ingenuity pays off! We agree with Drs. Stever and Press that the country would profit greatly from an increased effort in basic research, both industrial and academic.

It is important that the federal government view support of basic research in terms of supporting the research system in its totality. Three other issues deserve comment in this regard. They are: (1) continuity of research support; (2) condition of instrumentation in our university laboratories; and (3) manpower problems which we see for the future of chemistry and America.

At present, one of the most serious problems in the administration of the country's basic research effort at all levels relates to sudden budget cuts and withdrawal of funds. The American Chemical Society enters a strong appeal for increased stability in the funding process. The nation should make a longer term commitment consistent with its long-term scientific and economic goals.

Abrupt reductions in support for research are extremely wasteful of human resources. Discouraged scientists who leave the field for other employment become obsolete and cannot return to research. A long lead time then is required to rebuild the scientific manpower base. As will be shown, current projections indicate we can ill afford future losses of manpower in chemistry, in particular, the Ph. D. chemists upon whom research depends.

The federal government bears the responsibility for maintaining funding stability, since it supports most of the basic research in the U.S. At this point, we know of no enforceable way to ensure stability in federal funding. The concept of a multi-year authorization is good in principle. It would allow the Congress, with the cooperation of the executive branch, to set the upper limits in funding for different research programs. The major stumbling block, however, is the appropriations process which is normally an annual exercise, and which even went through three cycles last year.

Lacking sound suggestions for long term solutions, the Society joins those in the scientific community and the Congress who urge that the problem be carefully examined. The American Chemical Society and many other members of the scientific community would welcome the opportunity to explore with appropriate government officials possible solutions to this problem. We note further that the sudden creation and equally sudden termination or reduction of massive scientific and development programs—such as the space and synthetic fuels program—can have a very serious destabilizing effect on the entire scientific establishment. A sudden surplus of scientists due to termination of a large program can create problems in the recruiting of students. It raises questions of employment security in their minds. Scientific progress in the future will suffer.

Our colleges and many, if not most of, U.S. research universities are struggling with inflating costs, decreasing enrollment, and various facility problems. One problem which concerns the American Chemical Society is the reported inability of U.S. colleges and universities to provide the instruments and equipment necessary for student instruction and the performance of research by faculty and staff. This problem has been discussed widely in anecdotal terms and by one survey report published by the American Association of Universities (AAU). The AAU survey showed a significant discrepancy between the age of university and industry instrumentation and equipment. The most significant consequence of this situation is that the training of students as experimental scientists is neither in keeping with the needs of industry nor with that of the discipline. Replacing worn-out instruments and laboratory equipment, and updating laboratories with new, significantly advanced instrumentation, are extremely expensive propositions. Advances in instrumentation have been occurring at a furious pace, principally because of advances in electronic hardware and computers.

The consequences can be severe when new instrumentation or equipment cannot be obtained, or when obtained cannot be maintained properly. We are especially concerned because this is occurring at the same time investigators are being disestablished by insufficient research funding.

Research laboratories which are either improperly or inadequately equipped spawn inefficiencies. Much valuable time is lost when both students and faculty must struggle and improvise to obtain the instruments and equipment needed for their work.

NSF and GAO studies are underway on the instrumentation problem. In addition, the review by the Defense Science Board of the research and education capabilities of universities will include an examination of research equipment needs. ACS also has a survey underway in the area of chemical instrumentation. Attention will be given in the ACS survey to the wisdom of using funds originally intended for research projects to provide research instrumentation. It is hoped these efforts will shed further light on the situation and provoke some new thinking on how to deal with it. Additionally, attention needs to be given to the difficulties encountered by universities and colleges in selling and giving away equipment purchased with government funds. Current regulations make transfer of equipment between institutions difficult.

All these issues, especially funding, warn of a problem we believe lies ahead. Will the United States have an adequate number of chemical professionals to operate the chemical enterprise in the next 5 years? We believe there is cause for concern. Already there is a very serious shortage of Ph. D. analytical chemists. This problem is so severe that a chemical industry panel is investigating our options as a profession. Further, the shortage of Ph. D. chemical engineers is a very critical national problem. Survey data indicate that the shortage of professionals will get worse before it improves.

Data in the recently published Science Indicators 1980 give a perspective on the size of the human component in chemistry and related fields. In 1978, there were 125,700 chemists and 57,800 chemical engineers employed in science and engineering. Based on these figures, we estimate there will be 135,400 chemists and 61,100 chemical engineers in science and engineering jobs in 1982. Sixty-five percent of the chemists and 58 percent of the chemical engineers work in R&D, with the engineers concentrated in development, and the chemists evenly distributed among basic research, applied research and development and R&D management. Next to R&D, the largest concentration of chemical professionals is in production and inspection, with 16 percent of the chemists and 23 percent of the chemical engineers in these fields. The third largest category is teaching, where 11 percent of the chemists and 3 percent of the chemical engineers are found.

To maintain this sizable establishment, our nation's colleges and universities turn out trained chemists at three levels, B.S., M.S., and Ph. D. A major protion of the chemical research and development work of the country is spearheaded by well trained Ph. D.s. The supply of chemistry Ph. D.s, therefore, concerns us. In 1970, the United States produced 2,235 Ph. D.s in chemistry. That was our high watermark; since then there has been a steady downturn. In 1980, the country produced 1,538 Ph. D.s in chemistry. By way of comparison, 1,594 Ph. D. chemists graduated in 1966, and the supply in that year was judged inadequate for the nation's needs. To further complicate our current problem, a sizable fraction (22 percent) of the 1,538 Ph. D.s produced in 1980 was composed of foreign nationals, most of whom will not be available for the U.S. labor force. Further, the number of U.S. citizens reaching the age of 18 will be declining over the next 10-year period (from 4.2 million in 1980 to 3.3 million in 1990) and the interest of high school graduates in science and mathematics is declining. We have good reason to be concerned over these facts and trends. It appears the pool of talent required to operate America's chemical enterprise is shrinking at a time when opportunities for discovery and development are on the upswing. American industry will suffer from an inadequate pool of technical manpower. The problem deserves serious examination by industry and academia, and particularly by government, since it is closely coupled to funding of research and development.

Up to the present time, our presentation has not addressed the question of possible savings in the R&D sector. We agree with Drs. Keyworth, Press and Stever that applied research and development are principally an activity for the private sector and will be pursued by industry except in the special cases of defense, space, and nuclear technology. As government moves out of applied research, development and some demonstration activity, the freed up federal resources might profitably be used to support basic research.

Difficult decisions are involved in achieving the necessary overall savings in the broad array of federal programs running from research to development and demonstration. These are policy decisions which involve the consideration of many more factors than only the quality of the work performed. In general, we welcome any opportunity which federal agencies give the scientific community to participate in policy decisions. The American Cehmical Society stands ready to cooperate with agencies in setting up review panels in agencies where they do not already exist. The Society hopes that the agencies will utilize the advice of these panels in formulating R&D policies and allocating R&D funds.

I should reiterate that setting priorities among NSF research thrusts is extremely difficult given the fact that the Foundation has the charter for broad support of research across all fields, and that the potential of basic research projects cannot be evaluated precisely. A similar ranking of research programs in mission agencies would be somewhat easier since these programs can be ordered according to the extent they are expected to advance the mission of the particular agency.

To conclude, I note that Dr. Keyworth has cited the example of the high-energy physics community completing a ranking of research priorities within its field. The American Chemical society congratulates the high-energy physicists for their accomplishment and hope we can learn from their experience. We should point out, however, that chemistry, in contrast to high-energy physics, is a wide-ranging field where a diversity of thrusts and opportunities for research exists. Setting priorities among all these thrusts would be much more difficult than within a relatively narrow field of investigation such as high-energy physics.

Mr Chairman, our testimony can be summarized in the following eight points:

1. Chemistry is a "central" science with a tremendous impact on the present and future economic vigor of the country.

2. The federal government has significant responsibility for the support of basic research in the U.S.A. Industry will not take up the slack from inadequate government funding.

3. Currently available information on the two major agencies funding basic research in chemistry indicates there is little hope of effecting major savings in basic research budgets by more careful "discrimination and area selection." While the thesis sounds attractive, the results of current evaluations indicate that cuts will involve "muscle, not fat." Still, the American Chemical Society stands ready to cooperate and assist in any evaluation projects undertaken by the government. We pledge our help if needed.

4. Considering that NSF can fund only one in five research proposals by first-time applicants, the American Chemical Society believes that an increase in the basic chemical research budget is justified.

5. Continuity and stability of research support is a major problem in basic research management. Abrupt changes and uncertainties in funding cause very serious management problems which can have a negative impact on the entire research enterprise. This problem deserves the attention of all of us.

6. Recent reports suggest that U.S. academic laboratories have aging and inadequate equipment in chemistry. The ACS is involved in ascertaining the severity of the situation, and what should be done to correct it.

7. An extrapolation from current data suggests that there could be a severe problem in the next five years in relation to the supply of chemical professionals, in particular Ph. D.s.

8. With few exceptions, applied research and development is an area for private rather than public support. A shift of federal funds from these areas to basic research could be beneficial.

The contribution of the chemical sciences to the economic growth and to an improved standard of living in the United States in the past decades is well documented. The Society appreciates this opportunity to urge that the knowledge base which has made this progress possible be maintained in a healthy condition by appropriate funding of scientific research.

Mr. Fuqua. Thank you very much, Dr. Parry.

Our next witness will be Dr. James Watson, Nobel laureate and member of the delegation for basic biomedical research and director of the Cold Spring Harbor Laboratory in New York.

STATEMENT OF DR. JAMES WATSON, NOBEL LAUREATE, MEMBER, DELEGATION FOR BASIC BIOMEDICAL RESEARCH, AND DIRECTOR, COLD SPRING HARBOR LABORATORY, LONG ISLAND, NEW YORK

Dr. Watson. Mr. Chairman, I come here as a member of the Delegation for Biomedical Research but I should say we are a rather informal group and the views I express are my own.

I have read the earlier statements of Dr. Keyworth, as well as Dr. Press, and Dr. Stever. I will frame my remarks largely in terms of my reactions to Dr. Keyworth's summary of the Reagan administration's position on the current state of American science.

I will talk about several matters. One, is his view that a shake out now in science funding wouldn't be a bad thing because we have expanded rapidly and there is a lot of waste in the system and that only in times of adversity will we face up to rot. I can only comment about those areas that I am personally connected with. I cannot talk about, say, the national labs, which Dr. Keyworth has experience with. Instead I shall comment on cancer research, now believed by many public citizens to have expanded too fast during the war on cancer—1972-82—when NCI money went up very rapidly. Between 1972 and 1974 I was a member of the National Cancer Advisory Board, and I think then that much money was, at best, haphazardly spent. Clearly the money went up

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faster than we had ideas. And so there was considerable waste but not much outrageous rot.

In particular, there were large contract programs without review, except by members of the staff. I think these conditions have been largely corrected. Today, contracts are only given out with peer review from people outside the National Cancer Institute. So, today we don't go around talking at length about people getting money that shouldn't. That, however, was a frequent topic of conversation, say as little as 4 years ago

There was also then the dilemma of what to do about cancer control. Congress wanted this effort, and told the NCI initially to spend $25 million maybe later going up to $100 million. This program was a total waste of money because there were no good ideas except to stop smoking which all too many Members of Congress did not want to hear. Maybe we could have then sanely spent $3 million. Now, however, the amount of money that NCI receives is almost in line with which they can wisely use. With other parts of NIH, money matters began to get tight as soon after Lyndon Johnson went out to NIH and said you guys have got to be practical. I think that was 1966. Up till then we really felt comfortable. But since my own efforts over the last decade has been in cancer research, I have not been so constricted. But the amount of money we get from NIH for what we call basic science research is very tight now. Many of the good labs are reaching the state where the amount of money left over for supplies and equipment is drastically down.

As a consequence, too large a percentage of the NIH grants now go to salaries. When this happens you begin to pay people to be around but not for doing science.

I remember very well when I was chairman of President Kennedy's Committee on the Boll Wevil, making a tour of Government labs working on cotton insects, to discover over 90 percent of their budgets went for salaries. That meant the boll wevil was going to be around for a very long while. Any thought that you were going to make it disappear was an impossible illusion when you are spending all your efforts to just maintaining the establishment, not asking what it is doing.

Up till now our Delegation for Basic Biomedical Research has devoted most of its efforts toward seeing that NIH can maintain the number of individual research grants so that we can maintain a fixed number of people doing science. We must also start looking at what percentage of grant moneys goes to salaries. If it is too high, you know that people aren't doing competitive science.

With regard to NSF, there can be little conspicuous waste. Far too many NSF grants are now almost absurdly small. As NSF has such a broad mandate it tries to cover a vast area, and now there are masses of grants in the size range of $20,000, effectively just peanuts, in terms of the total effort of a given research group. So the major support for biological research has had to come from NIH.

I think those staffs who labor so well in behalf of NSF have had a very difficult time in part because it has been national policy to increase the number of institutions doing a first-rate science, was say from 20 to 40, to between 100 and 200.

Excellent younger faculty have been recruited and a number of institutions which only marginally did real research now have the capability. Yet the size of the NSF has not gone up proportionally, thus the ever decreasing effective size of individual grants.

Now we must make the choice of either restricting the number of institutions that do first-rate science, or drastically increasing the budget which is going to NSF.

We, of course, have to worry as to where these increased funds must come from. Here we might first ask Dr. Keyworth, because he says there is all this waste in American science. So I assume he has already appointed committees to document this waste, so that the administration and Congress can begin redistributing the money to where it will not be misused.

The second major feature of American science which greatly concerns me is the education of our potential scientists. Every year we increasingly worry that the OMB is finally going to stop our fellowship programs. That will bring us back to the late 1940's when as a nation we first decided to encourage people to go into science by large national fellowship programs which recognize the best young potential scientists, and lets them choose the institutions at which they do research.

These governmental fellowship programs have given enormous vitality to the United States because they allowed young students to take a degree in one university, to move to another for their Ph. D., then transfer to still another institution for postdoctoral research. So much of the good science that has been done by Americans has been due to the mobility made possible by our rewarding and trusting in the good sense of our students.

I think we should contrast our program to Japan. Now, whenever we say Japan, we get frightened because they do most of many things better than we do. In science, however, they don't. For example, they have no fellowship programs. Effectively they treat their students lousy, their professors no better and still their journalists ask why they don't more often get Nobel prizes. The answer is simple: They have an archaic educational system for science at the university level and we have had a marvelous system.

Now many leading Japanese educators want to change their system, and I have been—traitorously—trying to help them. But, I don't think I or anyone else will succeed, at least over the short term.

In contrast we have been a wonderful place for science over the past 30 years. Now we have to be very careful that our academia does not fall back to the almost second level status we had before the Second World War.

As for the decreasing quality of American instrumentation in our schools, this sad state of affairs has been commented on repeatedly in prior testimony and there is no point in repeating such statements. I should say, however, that even if we spend much more money for instrumentation we shall not necessarily greatly increase the number of people learning science, as long as our leading universities officially remain so indifferent to whether those entering student classes know any hard science.

Now I think it is impossible to imagine the faculties at say Harvard or Yale or Princeton voting a science entrance requirement as once they required the classics. They are not going to announce—admit—that hard—as opposed to soft—science must be an integral part of any civilized youth's education. Given such scandelous indifference by our official educators, how can we provide the carrot that might make them change their minds.

Perhaps we should give out Government funds to universities to provide instrumentation on the basis of the amount of advance training taken by their students before they enter. If they enter with advanced standing in chemistry—image the whole class at Yale with advance standing in science—they would get more money in proportion to those that largely admit scientific illiterates. For example, if the students going to Northwestern University all knew some real science before they go there, then Northwestern would get much more governmental moneys than their neighboring universities that happily—haplessly—try to teach students who have never been exposed to quantitative ideas.

If a scheme of this sort came into operation, I'm sure that the presidents of our major universities, all in constant worry about their deficits, and knowing that they would get substantially more Federal money if more of their entering students actually knew some mathematics, would see to it that their admissions committees acted accordingly.

Likewise, our high schools have to face up to their dismally low objectives with all too many of their students having no concern for hard learning. With the time getting harder financially we can assume our youths will work a little harder. But real improvement might come by only giving money to high schools for science equipment on the basis of how well they teach their students—that is their national test scores.

This goes counter to the notion that we should be spending the majority of our efforts on those students who are far behind because of past cultural misfortunes. Now, however, I think we have to concentrate at least as hard if not harder on those who are now our best candidates, for future distinction in science.

I don't fear that my proposal, if enacted, would reward only a small number of schools. There are a large number of secondary schools in the United States capable of teaching science very well at the high-school level, and we might most wisely give them Federal money largely on hard evidence of their student's accomplishments.

I fear the past proposed remedies—summer school for high-school science teachers and all that—without asking something in return—will not succeed.

For they haven't worked very well in the past 20 years and we shouldn't conveniently say it has been because not enough money was handed out. The main point is that we cannot continue to be the leading nation in the world with our secondary school students so indifferent to the need of hard work as opposed to play.

And now to conclude, with my comment on Dr. Keyworth's position that as a country we should try not to be the best in every field. Given a nation of our size, to say that there exist major scientific areas where we do not strive to be the best is very bad public policy. I know a university which has quietly proclaimed that they only have money to be first rate in physics and mathematics. As a consequence, their chemistry and biochemistry are non-distinguished. Once we start saying that some American science isn't going to be the best, we shall end up not being in second place, but in third, fourth or even worse. Unless we try to intelligently plan to be the best in everything, can the United States remain the nation which has done the wonderful things it has done in the past 30 years through science? I fear not!

Thank you.

Mr. FUQUA. Thank you very much, Dr. Watson.

Our next and last witness will be Dr. Carl Leopold, who is a member of the American Institute of Biological Science from Ithaca, N. Y.

Dr. Leopold, we are very pleased to welcome you this afternoon. If you wish to summarize your statement, it will appear in the record in its entirety.

[The biographical sketch of Dr. Leopold follows:]

DR. A. CARL LEOPOLD

Plant physiologist, Dr. A. Carl Leopold, is a William C. Crocker Scientist at Boyce Thompson Institute for Plant Research, Ithaca, N.Y.

A former Dean of the Graduate College and Assistant Vice President for Research at the University of Nebraska, Dr. Leopold has also been a senior policy analyst in the Science and Technology Policy Office at the National Science Foundation and a professor at Purdue University. He was Assistant Horticulturist with the Hawaiian Pineapple Company.

Dr. Leopold holds the Ph. D. degree from Harvard University and is a former member of the Executive Committee of the American Institute of Biological Sciences and is a fellow of the American Association for the Advancement of Science. He is a member of several scientific organizations and serves on the editorial boards for several scientific journals.

The author of three books on plant growth, Dr. Leopold also has published about 200 scientific research papers and numerous other articles. He has held a Carnegie Visiting Professsorship at the University of Hawaii and has been a H.K. Hayes Memorial Lecturer at the University of Minnesota.

STATEMENT OF A. CARL LEOPOLD, WILLIAM C. CROCKER SCIENTIST, BOYCE THOMPSON INSTITUTE, ITHACA, N.Y., ON BEHALF OF THE AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

Mr. LEOPOLD. I would like to briefly summarize my statement. I have given you written testimony.

First of all, I think you have heard a unanimous voice from each of the speakers, both today and last month, on the importance of the Federal role in research funding, and I would like to comment on it just a little further, but with some specifics.

I believe I would like to open my remarks by emphasizing the close relationship between the effectiveness of the R. & D. sector and productivity in the manufacturing area.

The difficulty is that when inflation gets to be a binding issue in a society, we tend to cut back on R. & D. activities even though we know that the R. & D. effort contributes enormously to the productivity of the manufacturing sector; so this is the situation today where an inflationary period is settling on us and we are looking at our R. & D. sector and asking that tough question: Should we now cut back on our investment in R. & D., even though we know that it is such a basic component in productivity.

I will come back to this matter of productivity in a minute, but let me go on to talk about the trend in the research and development funding. Dr. Bromley spoke of the comparisons of funding and productivity in the United States, West Germany and Japan.

I would like to continue that comparison using some data that were published recently in Science Indicators of 1980, a publication from the National Science Board.

In Chapter 1 civilian research and development is reported as a percent of the gross national product in the United States; it has risen only 10 percent in the past 14 years. That is, 1968 was the high in research funding in comparison with the gross national product.

The comparable value for West Germany rose 30 percent, that is, a three-fold higher increase rate. In Japan it rose 25 percent. Let's compare numbers of research and development personnel. In the United States since 1968, our number of trained personnel has dropped 11 percent, and in West Germany and Japan it has increased 60 and 65 percent respectively.

Now if we believe that supporting the R. & D. sector is ultimately reflected in manufacturing productivity, then we should expect that manufacturing productivity in the United States should reflect our investment in R. & D. since 1968, and sure enough, during this same period, manufacturing productivity in the United States has risen 30 percent, and it has risen 85 percent in West Germany, and 290 percent in Japan.

With these numbers I would like to make the point that while we have essentially been experiencing a plateau of no gain in real dollars in the support of R. & D. in the United State since 1968, our relative position in respect to productivity has deteriorated substantially.

Each of the speakers this afternoon has mentioned the central role of basic research and the development of new areas of information that are relevant to technology. The basic research sector is, of course, the source of usually more than half of the new technological gains that are made in a given practical field; new technologies spring from the basic research area. Research support to the basic sector can be expected to provide approximately half of the major improvements in technology.

For instance, may I point, to the new industry of genetic engineering as a consequence of a basic research program. Genetic engineering was supported since about 1960, principally by the National Science Foundation, as a long-term investment in basic science. Today, of course, it is a new technological component in the economic world.

How well are we doing in the support of basic research? I would like to point out that it is rather discouraging that out of a total R. & D. budget of $35 billion in 1981, only 13 percent of this was for basic research.

Health-related research in HHS received only 5 percent of this R. & D. budget. The National Science Foundation received 0.9 percent of this budget, agriculture only 0.8 percent. This is really very poignant, because while the basic research areas receive such small support, the military sector receives 60 percent of the R. & D. budget.

Another component of R. & D. funding aspect which I think is relevant for your consideration is the return on your investment.

For most manufacturing industries, the return on your investment in research usually runs between 10 and 15 percent per year. In the past four decades the analyses have shown that investment in agricultural research, has produced gains ranging from 24 percent per year to 47 percent per year, and some estimates have been placed at even 90 and 100 percent per year return on investment in R. & D. The contrast with the military research productivity need hardly be drawn.

I would like to make one more point in relation to the funding of basic research and that is the funding of research in the plant sciences has been extraordinarily or uniquely poor. In the plant sciences, we are concerned with the commodity which constitutes the principal export from the United States. In the balance of payments it is unsurpassed in terms of its importance. I think it is very interesting that plant sciences, which produce such an important commodity, which provide such a very high return on your investment, are getting less than one-tenth of a percent of the R. & D. budget.

I have prepared a little list of problems that I see in the research community, particularly in the biological sciences, in terms of living with austerity in research funding. First of all, decreases in funding are more expensive than the simple dollar amounts that are taken away. The actual inefficiency produced from interruption of a continuous long-range program is very substantial.

The second point I would like to make is that the university community is especially vulnerable to cuts right now. The numbers projections of young people enrolling in universities in the next 10 years will decline, and Dr. Parry has mentioned this also. This is an especially vulnerable time, then, for the universities, and to cut the research budget now would be especially difficult for them.

As a consequence of the nonincreasing funding over the past 14 years, we have seen the development of a shortage of research and teaching positions in the faculties, so that to keep young people that are finishing training in the sciences is increasingly difficult.

A curious thing happens. When you have a hot field like genetic engineering, for instance, a diversion of personnel out of the academic field into industry means that the university community may have a particularly difficult time hiring people to teach these most important areas to students in training.

At the research level, the centers of excellence tend to crowd out the money for the smaller laboratories, and yet the smaller universities tend to be the source of much of the research staff for the centers of excellence. Both Dr. Bromley and Dr. Parry have mentioned the problems of training of science personnel, and also Dr. Watson, so I won't mention that again.

The research equipment problem is also very serious. Another one is the maintenance of an effective flow of personnel into the research community.

As the next to last item, I would like to point out that in my perception, the research community is experiencing a combination of discouragement about being able to maintain effective research programs because of the shortage of funding, and along with an increasing cost in the competition for money. The National Science Foundation has just completed a study of the amount of time that faculty invest in the search for research support. They found that at one of the major universities of the United States junior staff were putting in a third of their time in the search for research support.

I would like to make one last comment in relation to Dr. Keyworth's testimony. He said some very nice things about the science community. He said a lot of the things that we here at this table have said this afternoon about the importance of research in terms of maintenance of productivity, in terms of technological excellence. But he concluded that research was due for a decrease in funding, and he compared it to the pruning of a tree to maintain its health.

I submit to you, Mr. Chairman, that a reduction in research support for our community at this time is not the same as pruning a tree. It is in fact much more comparable to removal of the supply of nutrients, no again, I see no way that improvement in efficiency could be obtained by shortening the budget.

Thank you very much.

[The prepared statement of Dr. Leopold follows:]

February 3, 1982

Testimony before the

House Committee on Science and Technology

by Dr. A. Carl Leopold
William C. Crocker Scientist
Boyce Thompson Institute
Ithaca, New York 14853

on behalf of
The American Institute of Biological Sciences

I am pleased to appear before this committee to discuss Science and Technology Under Budget Stress.

I believe that there is general agreement among the various persons who have been testifying before this committee that the increasingly technological base of the country's economy makes it dependent to a large extent upon the advances of science, research, and development. The capability for economic growth depends to a considerable extent on the health and continuity of the flow of information and skills and trained personnel from the science community.

Federal Role in Research Funding

For some thirty years the federal government has played a major role in supporting research and development. Such support has proved to be a vital investment in economic growth, and one that provides a good return in terms of enhancing productivity , in addition to providing a continually improved knowledge of man and his biological and physical environment. These refinements in knowledge may be as important as the contibutions to the economic productivity of the country. For the purposes of our discussion today, the present concern about the economy causes us to focus our attention expecially on the economic returns from

R & D.

An interesting article was published by Professor Mansfield from Pennsylvania (Science 209:1091, 1980) concerning the relationship between R & D and inflation. He pointed out that industrial productivity is closely related to the level of R & D support, especially basic research done ov[illegible] long term. He pointed out that although improvements in indust[illegible]ductivity provide a strong force against inflation, it is generally true that as inflationary pressures increase, there often occurs a discouragement about investment in R & D, both at the industrial and the federal level. In inflationary periods, there is a tendency to cut back on the investment in R & D, which could otherwise be providing new potentials to improve productivity and to hold down inflation. I believe that the present situation of proposed cuts in the R & D budget at a time of inflationary pressure is precisely the sequence Professor Mansfield described.

Trends in R & D Funding

As a background for my remarks concerning science and productivity, I would like to review for you some facts which have been published recently in the report of the National Science Board, entitled SCIENCE INDICATIORS, 1980. The first chapter of that publication describes the extent of federal support of R & D, showing that since 1968 there has been essentially no increase in support for this sector in terms of constant dollars. I shall use comparative data for the United States, West Germany and Japan in several aspects of R & D. First, civilian R & D as a percent of the GNP rose only 10% in the United States during the past 14 years; in West Germany it rose 30%, and in Japan it rose 25%. In this same period, the number of R & D personnel in West Germany and Japan have increased 60 and 65% respectively. Our initial assumption is that these differences in R & D should be reflected in manufacturing productivity, and in fact, during this same period, manufacturing productivity rose 30% in the United States, 85% in West Germany and 290% in Japan. The point I wish to make with these statistics is that for 14 years our investment in R & D has shown no increase in constant dollars, and this plateau in the R & D sector is reflected in declining strength in terms of R & D personnel and in manufacturing productivity, in striking contrast with West Germany and Japan.

A Central Role for Basic Research

I expect that you are finding complete agreement among those testifying for your committee that basic research is the component of the R & D sector which is most fragile and is the source of unexpected and dramatic technological gains. The rocketing of genetic engineering into the technological arena is an impressive example of payoff that comes from basic research. The new industry arose after nearly two decades of research support, essentially by the NSF, for basic studies of nucleic acids. Sustained and steady support of basic research has proved time and again to provide a flow of new technology into the economy.

A discouraging aspect of the federal R & D investment is its distribution. Out of a total R & D budget of $35.5 billion in 1981, only 13% was for basic research even though basic research is known to be the immediate source of between 40% and 60% of the advances in technology. Health-related research (HHS) receives only 5% of the R & D budget, NSF only 0.9%, agriculture only 0.87%, and the military receives 60%. It is a poignant paradox that basic research in constructive knowledge areas is encouraged so little. The poignancy is even more acute when one realizes that the return on the investment is very high. In manufacturing industries the return on research investment ranges usually between 10% and 15% per year; in contrast the return on United States investment in agricultural research in the past four decades has been between 24% and 47% per year. It is curious that the country's greatest export commodity receives so little research support and at the same time it yields such high returns. The contrast with military research need hardly be drawn.

Before leaving the issue of the distribution of research support, I would like to call your attention to the singularly low research support given to the plant sciences. I estimate that in 1981, the federal investment in plant research was less that $25 million, which amounts to 0.07% of the R & D allocation. Considering the central role of plants in the production of food, and their role as the source of the largest export in the balance of payments with other countries, I find it astonishing that plant sciences held to this miniscule proportion of R & D support.

Living with Austerity

Several particular problems may be anticipated to follow a lessening of federal support for science and technology at this time.

(1) The interruption of long term research creates a serious inefficiency; restoration of funds in another year when inflation has been brought under control does not make up for the losses.

(2) The university community is especially vulnerable to financial setbacks now and in the coming decade, due to the lowering enrollments which are already causing financial difficulties on many campuses and resulting in losses of faculty strength.

(3) The shortage of research and teaching positions in universities is resulting in the dispersal of trained personnel often into employment areas which are outside of the research sector.

(4) Research areas with the greatest technological promise are expecially vulnerable to the losses of faculty to business sectors; the area of genetic engineering is a good example of one with great technological promise in which there is a shortage of trained personnel for university positions. In a recent editorial, D.A. Bromley (Science 213:159, 1981) compared the losses of trained people from the university marketplace to the eating of the seed corn in the American Indian culture. The loss of professionals from the education sector can have an irreversible effect in hindering the production of new professionals for lack of people to teach them -- an act which almost guarantees a professional famine in the future. The shortage of educators has already occurred in the engineering disciplines, computer science and genetic engineering.

Another consequence of a shortage in science funding is that the laboratories of the most prominent experts tend to dominate the available money, with the consequence that researchers at junior levels and in smaller universities may be preferentially excluded. The concentration of funding in the most prestigious laboratories can seriously impede the development of younger staff and can interfere with the flow of student training in the smaller or less notable universities.

The training of science personnel is an area that already is in trouble. Major reductions in science education already in effect will certainly hinder the flow of trained scientists in the future.

The problem of maintaining research equipment under the present budgetary limits has been mentioned by each of the previous testimonies you have heard.

In a more general comment, I would like to report that there is a combination of discouragement about being able to maintain an effective research program in the academic laboratories due to the increasing limitation of financing and of students, and ineffeciency in terms of the pressures and competition for obtaining research funds. Some very talented researchers among my acquaintances have almost ceased to function in research for lack of funds. The competition for grants is so keen that a large proportion of a researcher's time is often spent in competing for grants. A recent study carried out by the NSF indicates that in a sample university, young professors are spending an average of one-third of their time pursuing grants.

Comments on Dr. Keyworth's Testimony

I have found the earlier testimony of Dr. Keyworth before this Committee to be especially interesting, and would like to make some comments on that testimony. He made some excellent remarks about the importance of civilian R & D, including the following: "Support of science and technology -- especially basic research -- is a long-term investment that represents an essential element in the foundation of a healthy economy." He emphasizes that "this administration views basic research as a vital investment with a good return," and again that "basic research warrants government support because it is an investment in the future -- in a better quality of life, better security, better economy and simply better understanding." On the other hand, he feels that: "We cannot realistically expect to accelerate spending for R & D in a period of fiscal austerity." In his conclusion, he states that "the growth that science and technology have enjoyed for so many years cannot continue," and that changing goals call for changes in science policy. There is room for debate about whether science and technology have enjoyed growth for so many years, in view of the almost unchanging R & D budget in constant dollars since 1968, and in view of the actual decline in national expenditures for R & D as a percent of GNP. The intent to cut the investment of R & D in these inflationary times seems to be an enactment of Mansfield's generalization that inflation discourages investment in R & D which would otherwise hold out promise of alleviating inflation.

As a last comment, I would like to mention the simile used by Dr. Keyworth about benefitting the health of science by making cuts in the budget. He compared it to the occasional pruning of a tree to promote its health. It is my opinion that lessening the financial support for science is not comparable to pruning, but rather to a reduction of the nutrients which sustain the tree's growth. I see no way in which lessening the financial support for science can benefit its health, and I urge this committee to strive for the effective maintenance of the health of science.

Mr. **Fuqua**. Thank you very much, Dr. Leopold, and all our witnesses, for your very informative and thought-provoking comments.

Dr. Bromley, you mentioned priorities and that is one of the big problems that we have in this committee. I am sure the administration is trying to establish priorities, where do we spend and how do we accomplish this, not only in the R. & D. budget, but also in the total budget process as a whole.

You mentioned that you are not going to give us any help on that because it was a political decision, and I agree with you somewhat. But when we make political decisions and priorities, we wind up as Dr. Watson pointed out, maybe emphasizing the wrong things or putting too much emphasis, as in the case maybe of the cancer research at the outset of that program.

In the political process, how do we avoid making those types of mistakes, if you turn it over to us or to the administration, or whomever, as long as it is a political body. What we need, I think, is really scientific help and assistance as to how we arrive at these priorities.

I ask that of you because you mentioned the priorities, but maybe some of the other witnesses might like to address that question.

Mr. **Bromley**. Let me only say, Mr. Chairman, that I wish I had a clean-cut, concrete answer for you. It is one of the most serious problems we face. I think that to expand a little on the shorthand I used earlier, it is, I believe, largely a political decision. However, I believe that we can have much more effective input from the scientific engineering communities to the decisions that you gentlemen must ultimately make than we have in the past.

For example, I am impressed by the extent to which Dr. Keyworth has made a point of consulting with the scientific and engineering communities thus far in his tenure. We have heard the statement made by him that he plans to reinstitute a senior science advisory committee to bring input from science and technology to the highest levels of Government.

I feel, also, that perhaps we have not been utilizing the scientific, engineering, and technical advisory panels in the agencies to the extent that perhaps they might be utilized. We can provide you, and we should provide you, sir, with alternatives, estimates of feasibility, estimates of risk, and this sort of thing, to make your decisions as informed as they can be within our present state of science and technology.

Mr. **Fuqua**. Do any of the other panel members wish to comment? Yes, Dr. Parry.

Dr. **Parry**. Mr. Chairman, I believe that one of the points that we note is that the kind of result Dr. Watson was referring to frequently results from a rather emotional or a rather sudden response on the part of the Government to a problem, be it energy, be it cancer, what have you, and we note that the sudden creation of these large programs, and then their termination, causes a dislocation in the scientific community, which in the end does a lot more harm than good, and I believe that in the creation of many of these projects, adequate scientific advice relative to the reality of the options and reality of the goals that are set, would be most useful.

Mr. **Fuqua**. I want to point out, too, that not all of the decisions that the Congress has made have been bad. I recall in the post-Sputnik era that I think Congress responded in a very appropriate fashion in not only creating the National Aeronautics and Space Administration but also in the various science education programs and beefing up of the National Science Foundation, in trying to cope with what was then a real national problem. I am afraid we are approaching that again at this time, that we are finding ourselves back in that same posture.

Dr. **Parry**. I believe that the decisions which you referred to were extremely good, and I think they were made with a lot of consultation with the scientific community.

Mr. **Fuqua**. That is correct.

Dr. **Parry**. As to what was possible.

Mr. **Fuqua**. I also want to acknowledge the presence, as has been mentioned earlier, of Dr. Fred Basolo, the incoming president of the American Chemical Society. We are very happy to have you join us.

I thought one of the other very interesting points, and I think it has been made by many—Dr. Bromley pointed it out—was that we not enter into any type of crash program. One of the things that has concerned me, is that we establish a policy that is well thought out, but that we follow through with it.

I am not concerned about a crash program but a well-designed program to achieve the ends, and I think in many cases in recent years, with maybe some exceptions, there have been very well thought-out programs.

The point of stability in program funding is important, because you just can't turn it on and off, as you can maybe some other programs.

Mr. Brown.

Mr. **Brown**. May I say that I have been very impressed with the testimony of all the witnesses this afternoon. I think it represents a real contribution to our thinking. I was stimulated by the suggestion that you made, Dr. Bromley, that perhaps we ought to separate the research from the development aspects in our usual thinking about the R. & D. formula, and I can see considerable merit in that.

I want to just explore briefly the fact, and it is true, you have indicated, that in periods of stringent budgetary situations we may tend to cut unduly in basic research, if we are not careful. We need to have a long-term framework for examining this. But I am inclined to feel that there are many in the Congress, and probably in the public, whose support for basic research is not founded on an understanding of the long-term importance of it, but perhaps is due to a feeling that basic research is always coupled with some outstanding public good.

For example, I comment fairly often that the post-World War II support for R. & D. may have stemmed from a feeling that whenever you apply science to meeting a problem like defense, it always produces something amazing, like a nuclear weapon or something like that.

And so I raise the question that if we uncouple them, do we not need to do something about inculcating a feeling of strategic importance, that is, the long-term importance of basic research, and to substitute for this rather emotional cause/effect the idea that a dollar on basic science always causes a dollar increase in GNP or defense? I ask you to comment on that.

Dr. **Bromley**. I would agree with you entirely, Mr. Brown. I think that if we face up to it, since World War II support for basic research was tied to military questions, and as you well know, back in the early seventies President Nixon tried to tie support for basic science to energy.

This has turned out not to be a particularly successful tie, and this is very much behind the reason that I have been arguing for the development of a new constituency for science.

Just as you say, I think that between us—the scientific community, political community—share the responsibility for developing this constituency. I am perhaps a little more optimistic than I sense that you are, sir, because in terms of science per se, I have been very pleased in the last year or so to see evidence for a real hunger on the part of the public for authoritative accessible information about science.

The explosion of popular science magazines—Science 1982, Discovery, Quest, you name it, new popular scientific TV programs and the like—gives me some encouragement that perhaps our task isn't going to be as rough as we had thought.

But we really have to work at it to develop this constituency, and I think that if we can separate the R from the D, focus on what we are trying to do in the two areas, and the goals are different, that we can do something very worthwhile for the Nation.

Mr. **Brown**. Dr. Watson.

Dr. **Watson**. Yes.

In separating these two, I think we should also separate our defense-related science because we and the Russians uniquely are doing it on a grand scale, and we have to ask whether this, in the long term, is possible.

As long as we continue our current course we should have a tariff on all items from countries which do not spend any real money on defense, on, say, every Japanese car there should be a tariff to go to support American science. The Japanese reaction would be a sense of outrage, but on the other hand we now rightfully have a sense of outrage. Maybe they would balance. This move would give us the money to keep doing science at its best.

As long as we are carrying such a disproportional component of the free world's defense effort, we shall deemphasize that research which keeps us healthy economically. So at least over the short term we should place a modest surcharge on Japanese cars—$300?—Japanese TV's, et cetera. Of course, there is an even better alternative—that we and the Russians should decrease our weapons-related research.

But if this is not achievable, I think we have no choice but to ask ourselves whether the American pure research effort increasingly has to be less effective than that of other major industrial countries. I cannot see our remaining a first-rate country with the continuation of our current policy. The sooner we separate defense R. & D. from the total picture, the sooner Dr. Keyworth will stop making speeches with such misleading statistics.

Mr. **Brown**. I think you are guilty of coming out with a lot of outrageous ideas. Dr. Leopold, I liked your analogy or your reference to the remarks made by Dr. Keyworth about pruning, but sometimes these could be dangerous analogies. Dr. Keyworth may have been thinking about animals rather than plants, although he used the plant analogy, where you remove nourishment and the nutrients tend to be focused in the brain and you get sharper and sharper all the time—you just lose fat, which we could probably all lose.

Thank you, Mr. Chairman

The **Fuqua**. Mr. Winn.

Mr. **Winn**. Thank you, Mr. Chairman.

I have been very interested in the comments today from this distinguished panel. I am somewhat disappointed in the title that we sent out to you in "U.S. Science and Technology Under Budget Stress." I would hope maybe that we could have had a subtitle something along the line of how we can do a better job for science and technology if we are forced to accept budget cuts.

I also have the feeling somewhere that we left an open door because of the first title or the main title to criticize this administration. I don't read that into much of the testimony, particularly when you use statistics that go clear back to 1960, or 1966, or 1969, depending on which statistics, and over half of you used some statistics showing that we have been on this course for quite some time, not just under this present administration.

Now, I realize that this present administration has told the Congress and told the world that we have to have some budget cuts, but I think, Dr. Watson, your comment—and I am not trying to pick on LBJ, but you go back to 1966 and you say possibly, that is when I think you said we got in trouble, in 1966, when he said let's be pratical.

We may be getting in trouble right now. But I would like to have your comments on a little different facet that nobody touched on too much, and that is what we might expect in the R. & D. field or science and engineering with the added tax incentives that this administration is proposing. Would any of you care to comment on the tax incentives with some more to come next Monday, as I understand it, but also the ones that Congress passed last year?

Dr. **Bromley**. Mr. Winn, I was merely going to comment that it may be a little early, given the time constraints of the R. & D. enterprise, for us to really be able to evaluate those tax measures. I would simply say that in my own case I would find it very difficult to evaluate. I am optimistic, but I would be hard put to respond to you in a concrete fashion this soon, because I don't think we really have had the chance to see how they are going to function.

Mr. **Winn**. Dr. Watson.

Dr. **Watson**. It is my hope that the chief effect will be on American industry itself, which has been spending far too little on R. & D. to maintain itself competitively. I can't really see them bailing out academic science through the 1981 tax incentives. We would not gain if industry concentrated on saving us academics and not themselves.

Mr. **Winn**. Dr. Parry.

Dr. PARRY. I agree with both the comment that it is too early to tell and the comment that the major benefit will be on industry itself. The American Chemical Society has made some effort to establish another trust fund like the Petroleum Research Fund, hoping that the tax benefit package would be an incentive for industry to contribute.

We find that that has not been a suitable incentive to get them to contribute to academic research. Whether the activities of the Council for Chemical Research, a newly formed group, will ultimately develop to any level in the future is still uncertain, but certainly the data up to the present time indicate that the council is having extreme difficulty, too, in raising money.

I would say that the data currently available indicates that industry is unlikely to be a large source of funds for basic research in the university community.

Mr. WINN. Have you all had the opportunity to tell Keyworth that?

Dr. PARRY. No, I haven't.

Mr. WINN. You talked about good communications. Communicate that to him.

Dr. Leopold.

Dr. LEOPOLD. I am much more optimistic about the effectiveness of industrial money in terms of the support of research on the university campus. At Cornell University we see quite a lot of activity already this past year, industry and industrial groups recruiting first-rate people to work on problems that they feel have an importance in the long term.

These are not developmental issues that they are interested to finance, but they are actually attempting to recruit really long-term basic research.

I think it can work. I think it isn't going to solve the problem entirely, but I am optimistic about it.

Mr. WINN. There are claims on the one hand that research facilities in the United States, are second to none in the world. We have read articles about those. Then on the other hand we hear that research facilities at colleges, universities, national labs, and other technology centers are old, obsolete, and decaying. That is a little confusing to many of us, and I just wonder if you care to give us your comments on that.

Dr. BROMLEY. I think that we have to distinguish, Mr. Winn, between the stars in our repertory and what we have throughout the universities and colleges, high schools of the country. We do in many areas have outstanding facilities that are not duplicated anywhere else in the world.

Mr. WINN. Those would be industry?

Dr. BROMLEY. Some in industry, some, for example, the 2-mile linear accelerator at Stamford, the big Fermi accelerator at Stanford, the big telescopes that are simply not duplicated elsewhere.

Where the real problem seems to emerge in the most striking fashion is in the colleges and universities where, as I mentioned earlier, we are literally teaching what should be frontiers of science and technology with instrumentation usually more than two generations old, so that it literally bears very little resemblance to what is out there in the actual real world.

And we have engineers who have graduated from our best engineering schools who must be run through a remedial course when they arrive at the industry with which they are going to work, so that they can recognize the instruments that are being used. And so I think we must distinguish carefully beween our frontier facilities—and we have them—and the general run of facilities in our teaching and research laboratories.

Mr. WINN. Does anybody else care to comment or differ in their opinions on that?

Dr. PARRY. Also this involves the difference between what one might call small research and big research. Big research involves large telescopes, large accelerators and this kind of thing, and America does have a large number of these.

Then we have small research, where the instrumentation is in smaller units and smaller laboratories throughout the country, and in universities and schools, and I believe that the problems in many, many of our small research operations are severe.

Mr. WINN. Thank you very much. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Winn. Mr. Lundine.

Mr. LUNDINE. Thank you, Mr. Chairman.

Dr. Bromley, I am interested in your comments on the manpower, or person power I guess we should say, the shortage in science and engineering. Other than supporting instrumentation and facilities, specifically what would you do to alleviate these shortages?

Dr. BROMLEY. Several things, Mr. Lundine. First and probably the most critical problem that I see is one that we have had with us for some time, and that is simply the decay of our secondary school system. We are not attracting people into the areas where the shortages exist, physical science, engineering, mathematics, computer science, and so on, nor are we providing them at the high school level with the kind of background that would be required for them to enter those professions.

It seems to me that what I would do there, very simply, is to rebuild some of the programs that made it possible for those limited number of dedicated, qualified, enthusiastic high school teachers, who generate a vastly disproportionate number of the leaders in these fields, to keep in contact with their professions.

The NSF summer program for high school teachers was in my view the best investment we as a Nation made in our future in high technology, in science, and engineering. That is disappearing. We are cutting ourselves off at the roots, because we are not bringing young people into the fields that are of importance to us as a Nation. That is point one.

We really focus on a limited number of teachers. Time and time again we find that a surprising fraction of the leaders in all of these fields come from a few key high schools in the most unlikely places, entirely at random across the country.

The second thing, apart from instrumentation and support and laboratory upkeep of the kind you mentioned, it seems to me terribly important that, just at a time when we begin to see an increase in students entering engineering schools, the faculty are disappearing out the other door. They are going off, quite understandably, to what are much more lucrative and challenging opportunities in private industry. But it seems to me that this is not a Federal problem. It is a problem that the private universities and the State universities and the private sector must address among themselves.

There are several things that have to happen. One thing that seems to be possible is that universities are going to have to give up the idea that all faculty are on the same salary scale. Universities have long learned to live with the fact that medical doctors and lawyers are different when it come to salaries in universities.

It may well be that the engineers will shortly have to be paid in response to market pressures, so that it makes it more possible for them to stay in the universities where they can train the next generation of technical people.

And I am optimistic, because already, as you may know, some of the private concerns in this country are addressing this problem Exxon, for example, already is engaged in a substantial program of relatively string-free grants to some 66 universities to help them retain people in engineering and physical sciences and mathematics. Exxon recognized that in the future they are going to need the products of those universities. That may be a start.

Mr. LUNDINE. One thing that may also help would be to promote better cooperative arrangements between universities and industry, and one thing that concerns me, if I understand it correctly, is that they can't get a tax credit if they contract some research to a university, whereas they can if they hire away the professor from the university. Is that not correct?

Dr. BROMLEY. First my understanding is far from total in this area, but I believe that what you say is correct. I believe that the way the tax laws finally emerged was not exactly what people had in mind during the discussions, and we may have to fine tune the process.

That is clearly one of the problems, but I could not support you more strongly in your view that we must work out better cooperative arrangements between the private sector and the universities. It is one of the major challenges we have in this country.

Mr. LUNDINE. Another challenge that you referred to, and some of the other panelists did, is the problem, the challenge of the defense need for higher technology in research, possibly taking from the private sector, which tends to improve our productivity and solve some of our economic problems. Do you have any particular reflections on how we can pursue our defense objectives without adversely affecting private nonmilitary research?

Dr. BROMLEY. There are many areas of concern here. The one that I think ultimately is probably the most important is that, again, of manpower. We have ever increasing sophistication and complexity in our weapons systems, in our communciations system in the military. But the basic question, it seems to me, is one of whether we can produce the kinds of people who will be able to handle those systems in a knowledgeable fashion and in an effective fashion under an emergency situation. It is far from obvious that this is the case.

I would suggest that there are two things that the Defense Department really must do in responding to this increased challenge. First of all, the Defense Department is going to have to work with universities to rebuild the bridges that were burned during the sixties and the seventies, because they need professionl engineers and scientists.

We need people, competent people coming in from the high schools, who can handle things that are essential to the Defense Department now. Also it seems to me that the Defense Department is going to have to pick up a substantial role in supporting science and education that they once had in the fifties, for example, and lost almost entirely in the sixties and seventies.

I think they are going to have to pick it up again in the eighties, if we are going to be able to carry forward in constructive fashion with the rebuilding that the present administration has directed will be undertaken.

Mr. LUNDINE. Mr. Chairman, I realize that my time has expired. May I be permitted to ask one specific further question, though?

Mr. FUQUA. A quick one.

Mr. LUNDINE. Dr. Watson, you made an interesting proposal to give money to the best high schools. Specifically, would you include private as well as public high schools in that?

Mr. WATSON. Yes. Our objective is to get well-trained people.

Mr. LUNDINE. Not only did you get a quick question but you got a brief answer as well.

Mr. FUQUA. Thank you. Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman.

I would like to address an obvious question to the panel. How would you go about deciding which programs to fund and which programs not to fund? One of the witnesses indicated that peer review was working well in this area but this is apparently the problem we are faced with.

We have a science adviser who says there are a lot of nonoptimized programs out of there. It was said that cancer research involved a lot of waste. My instinct would be that Congress wanted a lot of waste in the cancer program because of the type of problem it was.

There was probably a relatively unconscious but real decision made that this problem was so important, and the value of time so critical that it was an area in which we were not particularly concerned with waste, but apparently that is not true.

Another area is science funding. Is there a way that we can differentiate between these programs?

Dr. BROMLEY. If I could begin the answer, Mr. Walgren, by differing a little bit with you. I think that it is certainly my feeling, and I believe that of my colleagues on the panel, that there is not all that much of the less than excellent work in the system.

The point I was making earlier was that during a period of rapid growth, such as we enjoyed during the sixties, for example, in many areas I think one could legitimately claim that there was work that could be judged less than excellent in some fields. In rapid periods of growth, just as you say, sometimes you want to take risks. You are in a hurry, and you do things that if you were under tight budget constraints or had more time you perhaps would weed out.

However, the point that I tried to make earlier is that for about a decade we have been working in most of the fields of science and technology represented here on more or less flat budgets, and during that period of flat budgeting, we have already done the weeding, and it is not now a question of taking out the less than excellent.

Frankly, I don't know where this mediocre work is, and we are really cutting some things that are less excellent than others, but still excellent and still contributing in a major way to the well being of this country.

Dr. WATSON. I think it is natural in good times that you don't try to be too tough on your friends. I think you probably always should be a little tougher than we are. The problem now is not that one shouldn't be critical, but we seem to be in a situation where you can't do anything new.

I have the feeling that if you now go to NSF and argue for a big new program—there is no way of getting it done. What worries me the most is the lack of optimism that comes from the thought that you might start something new and important.

Dr. LEOPOLD. I feel as Dr. Bromley does that the pure science has pretty well been weeded out, and that cuts now are into the substance the real meat of the field. I would like to also respond to your question about how do you decide what areas need to be supported. I feel that it really would be most expeditious to let the science community decide where the money should be put.

Targets of opportunity come up, as Dr. Watson has pointed out, that don't fall in any particular category, and if you have a foundation to support basic research, let them decide where support can be put with the greatest efficiency.

Mr. WALGREN. Can you indicate where they would rank science education in general under the NSF budget as we expect to see it in 1983. We are going to be reducing science education by $5 million, and we are going to be increasing the effort in mathematical and physical sciences by $30 million. If you consider the Government's basic role in investment, where does science education fit in that priority?

Dr. BROMLEY. I would first not want to be attempting to defend all of the NSF science education program of the past. However, there are two areas of that program that strike me as absolutely critical, the first I discussed in answer to Mr. Lundine's question. It seems to me, with limited investment, to make it possible for the best high school teachers in this country to maintain contact with science. We had a program which had a remarkable return on investment. I would like to see us build on that earlier program.

The second thing that I would like to see is substantial expansion of a program of fellowships and grants to outstanding students selected on the basis of competitive evaluation. I don't in any way decry the need for other programs designed to correct social inequities or anything else. They are important. But what is critically important and what has been allowed to decay over the past many years are those programs where we select, identify and support the most able youth in the country.

To a disproportionate share, far disproportionate, our future and the future of our country rests in their hands. I think that anything we can do to identify them early, help them, support them, move them on their way is a tremendous investment in our future.

So, those two programs I would like to see us build on and build on effectively.

Mr. **Walgren.** Thank you, Mr. Chairman.

Mr. **Fuqua.** Thank you, Mr. Walgren.

I understand you agreed to yield to Mrs. Schneider.

Mrs. **Schneider.** Thank you very much. I thank my colleague for yielding.

I regret I appeared late for some of your testimony. However, I had my staff cover it, and I have all the information. Regretably I have to leave at 4 o'clock now for another meeting. However, I am critically concerned about the future financing of research. I am very concerned that it seems that we have a tendency in this body to respond to crises, crisis management, as has already been mentioned.

It is very apparent that you are responding to the need or we have responded a couple of years ago for increased funding for cancer, Rhode Island being the highest cancer death rate in the Nation, of course I am very concerned that money continues to flow into that area.

It is also obvious insofar as the space program is concerned, and communications technology and a broad spectrum of other things. What is particularly frustrating is that perhaps, as we say, it is difficult for us to maintain our lead, I sincerely question whether we do have a lead in many of these different scientific and research areas. And perhaps maybe we should, instead of responding to crises, have the scientific community clearly articulate a series of priorities that are based on a foresight, based on looking into the future as to what our needs will be.

I serve as part of a caucus here in Congress called the Clearing House on the Future which helps us to have less of a tendency to focus on the here and now, on of 2-year decisions, to focus instead on the long range.

Looking at places like Japan, where they have a tendency to have the government lend direction toward setting priorities, perhaps this is what we need to do. I am feeling your frustration of talking to an almost empty hearing room. I know what I am going to be doing on the science budget, but how am I going to persuade some of my colleagues to be doing that when they haven't been sitting here hearing what you have to say.

It seems to me that if all of you went beyond the measures of dedication of time and energy today to maybe have the AAAS or your individual bodies put together a comprehensive list of spending priorities for future research, that we would get national attention and the attention of some of my colleagues here, maybe we could be making better decisions. That is what I am really concerned about.

I guess I don't have so much of a question, but it is more in the form of a request. I just wonder what you think as to that kind of strategy or approach to getting the results that we are looking for.

Dr. **Basolo.** Since I have had nothing to say so far, perhaps I ought to justify my existence and comment.

I think what we have been hearing is really what needs to be said. At least in the area of basic research in chemistry—I happen to be a chemist—we have been policing the expenditures of what funds are available, very stringently, as Professor Parry indicated. Only one out of five proposals to NSF is being funded, and some very, very good young people, assistant professors, never get tenure because they do not succeed in getting funding, not because the proposal that they submit is not good, but simply because the funds available do not extend sufficiently to cover these proposals.

So, that we really are talking here, and you have been hearing it over and over, about priorities, about pruning, however you spell it. It is usually referred to as cutting out the fat. The fat has been cut out. You are working on cutting out the muscle. It is beginning to hurt a great deal. It is beginning to show up in a lot of places. I know we are all very much interested in defense.

When we mention being a superpower, the first thing we think about is militarily. We would like to be a superpower in technology, we would like to be a superpower in economics as well. Basic research really is the foundation for technology and economic advances countries make.

So, I think we better think about things in the right perspective. In defense, we like to be, and all of us agree, a superpower; but if the budget is $200 billion, there has got to be some waste, there has got to be something falling in the cracks. I am sure that basic research would be more than happy to pick up the things that fall through the cracks where defense is concerned.

It might be more profitable, rather than listening to these arguments over and over again that scientists are able to give you, that we have already cut right down to the muscle, to have somebody look at where the bulk of our funding is going and see if there can't be some savings there without detriment to our defense, of course.

Thank you.

Mrs. **Schneider**. Yes.

Dr. **Bromley**. If I can add to that, you have asked, as you well know, one of the very difficult questions, where do we place our bets for the future. And it is incredibly difficult within a science to get agreement among the people in the science as to the priorities. It becomes vastly more difficult when you move outside of a specific science and consider priorities between sciences.

So, even with the best will in the world, I think that, speaking on behalf of AAAS, I would know of no way in which I could get an agreement from the members of AAAS on anything I could present to you.

But I come back to the fact that in our system of government, it is, after all, the responsibility of the executive branch, Dr. Keyworth, his associates, to formulate a program to present to you folks for consideration.

I hope that the system will develop in such a way that there will be more scientific, engineering, mathematical, general scientific input to the processes within the executive branch. That approach will formulate at least the first cut at a program which will benefit from consideration by committees like this one, from discussions throughout the scientific community.

But, it seems to me that is where we have to start. And getting more input into that discussion, and getting the discussion more informed, is a first, if certainly far from sufficient step.

Mr. **Fuqua**. Did you wish to comment, Dr. Watson?

Mr. **Watson**. Yes; we are trying for the impossible by having our Government run for the large part by people who are almost totally ignorant of science and engineering when the economic basis of our society is technology.

Dr. Keyworth must have a very difficult time operating with virtually no staff and as far as we can tell, not a very high place in the Government. I think we are getting just about what our administration wants—indifference to scientists.

I mean I don't see how we can if within the administration the role of science is so small in an official sense to think that in fact it is going to affect our decisions is ludicrous. Fortunately our Government is split, and we have Congress. Of course, I think your role has to be even more important than in the past in seeing we try and rationally run our Government.

We have talked about voodoo economics. Vice President Bush once used that word. You know, we are almost asking for voodoo science. If we don't have, you know, we want the great things, but we really don't have trained people to do it. In the last analysis we are going to rise or fall over the number of people of competence who can run our country. And I think the question is, is science education important? It is very important. And we cannot have that number decrease without having a real crisis develop.

Mrs. **Schneider**. Well, I just would like to make one closing comment. We may have limited technical expertise in this area. But, yet, we are the ones who have to make the decisions. And for example, the Energy Research Advisory Board has made recommendations as to the most cost-effective investments of research dollars in energy.

They have given us their priorities. It just so happens that, you know, that will certainly help us in making decisions. Now, we have a whole panapoly of different decisions to make on research. Now, do I want to vote to put a lot of money into space research, or do I want to put more into health research or energy research, and that sort of thing.

All I am suggesting is that if the scientific community, granted, it is difficult for maybe two of you to talk to one another, but when you get three, it is even tougher, but I think that that kind of thing needs to happen. This needs to happen in order to provide some national directive for effective spending of our dollars. And, if that kind of initiative could be taken by the scientific community, I think that you would see this body much more responsive to that kind of direction.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mrs. Schneider.

Mr. Shamansky.

Mr. **Shamansky**. Thank you, Mr. Chairman.

Dr. Parry, my home is Columbus, Ohio, and one of your most important divisions, the Chemical Abstracts Service is there. And it sits on one side of Ohio State University and the Battelle Memorial Institute sits on the other.

Last week the president of Ohio State was here having lunch with the Ohio delegation. He pointed out that it would take $50 million to bring the instrumentation of Ohio State up to where it should be to train our future scientists. I just talked to one of the vice presidents and I am going to take a tour. He said Suburban High School has a better chemical lab setup than does the university at this point. I don't see how in the world my community, and I am very locally oriented, can continue to enjoy the economic strength provided by Chemical Abstracts Service if the supplier of the personnel in a significant sense, Ohio State University, is just not turning out people properly trained.

I would like to know from you what your professional society thinks it can do other than coming here to inform the handful of us who come by.

Dr. **Parry**. At the present time we have a task force looking at the issue of instrumentation to try to get a more considered answer to the question you have asked me. It is a tough one, and the decisions that are put before us are, Can we take the money that normally would go for research grants to try to build up this instrumentation?

Mr. **Shamansky**. Is that robbing Peter to pay Paul?

Dr. **Parry**. This is exactly right. There is a question, then, as to whether or not this is a wise decision. The obvious answer is an infusion of a sizable amount of money would be needed to bring Ohio State up to where it should be, and this problem is not unique to Ohio State.

Mr. **Shamansky**. I think it is typical. That is what worries me.

Dr. **Parry**. We are now talking about bringing university laboratories up to where we would be competitive even with American industry, let alone with laboratories in other countries. And the real problem is, where are you going to get the money for this. The only option we can see is that among the development and demonstration projects, there may be many that industry would be willing to pick up and that might free some Federal money for other uses.

Mr. **Shamansky**. Frankly, sir, that leads me to my next question. I would like to suggest to you, at least as far as I am concerned, that this pleading by the administration of no money is a very self-serving declaration. This committee, on a bipartisan basis, eliminated about $240 million for the Clinch River Breeder Reactor. Then, the administration mobilized itself, as a favor to Mr. Baker. It put back $240 million for the Clinch River Breeder Reactor, Mr. Baker being from Tennessee.

That could fund a lot of science education and a lot of instrumentation. So, this claim that there is no money, and that there is no money for this, but there is plenty of money for other things.

I think that when you see Dr. Keyworth, I urge you to point that out to him, because he ends up nothing but an apologist. I mean, that is what he is hired to do, unfortunately. The question is, is he an apologist for the administration, or is he a spokesman for science? Now if he has no staff, as Dr. Watson says, obviously, he can't be much more. He is a hired apologist.

Dr. **Parry**. I could only indicate that the need for money for the instrumentation is severe. I am glad that you folks are worrying about where the money comes from. That is not in my province. But, I do believe, firmly, that without some attention to instrumentation and other problems which we face, we will slip into a second-rate position in the area of science.

Mr. **Shamansky**. I would like to comment that my law school classmate, John Hare, is president of the council on financial aid to education, which advises the large corporations on how they spend their money. He talks about working with these large corporations, Exxon and so on, to help. But it is a spit in the ocean.

Dr. **Parry**. Right.

Mr. **Shamansky**. Don't have any illusion. I don't want to say it is a PR job. Every penny helps. But it is not addressing the major problem. Before I yield I would like to say to the two witnesses from the American Chemical Society that your Chemical Abstracts Service headed by Dale Baker is an important part of our community and they do a good job.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Shamansky.

Mr. Nelson.

Mr. **Nelson**. Thank you, Mr. Chairman. First of all I want to make a statement that my eye caught in Dr. Leopold's testimony here, in which he concluded that it is his opinion that the lessening of financial support for science is not comparable to pruning, but rather to a reduction of the nutrients which sustain the tree's growth. And I concur in that conclusion. Now, Let me pick up.

One of you sort of compared the advancement of science and technology, as an either-or proposition, with regard to the defense budget. And I think the statement was, where you can tighten up, where you can eliminate waste and duplication in the Defense Department, let that fall through the cracks, and we in science can utilize that.

Then, my eye caught Dr. Bromley's testimony, where he is talking about the inner relationship between defense matters and science. And the cross-pollenization, if you will, between the two. I would like some more comment from you as to that, because being on Chairman Fuqua's committee, and also being on the Budget Committee, where we get these competing demands for the allocation of how big is the slice of the pie going to be in this or that sector, and of course, frequently there is the assault on defense, saying, well, we ought to cut down defense, and then we can provide for more social programs.

You know, I heard a rendition of that with regard to science here. Give me some commentary on that. Dr. Bromley, perhaps you might want to illucidate, please.

Dr. **Bromley**. Thank you, Mr. Nelson.

Yes, I happen to feel that both the scientific and technical community, the Department of Defense, and the Nation were all hurt when we had the major schism developed between the research community and Defense Department in the sixties.

It seems to me that in a democractic society like ours, the people responsible for our security and defense should neither be nor feel to be cut off from the major body of society. I think it is terribly important first from a philosophic point of view that there be continuing interaction between some of the bright young people in our country and the people responsible for the defense, and that they be one and the same part of the time.

So, they think it is terribly important to get the communication going. Then I come back to the fact that the Defense Department has a desperate need, if it is going to do the thing it is being charged to do by this administration and past administrations, defense is becoming a much more technological enterprise than it ever was.

Mr. **Nelson**. Precisely.

Dr. **Bromley**. We are seeing a need for people who are at a level of training and expertise that transcends anything we have seen before in the defense community. It seems to me that on all these grounds, it is essential that we begin to make common cause, that we begin to recognize that, for the good of the country, the Defense Department has to go back to some of its old role of being one of the supporters and participants in research activity and science education.

It is going to draw on that system for people and ideas and concepts and devices. And on the university side, the universities have to get involved to bring new points of view into the Defense Department, to the discussions and to the priority decisions that must be made there.

I would end by saying that a two-way street is not anywhere near enough. What we have to have is a three-way communication among the private sector, the research community, particularly in the universities, and the defense area.

So, I for one feel that we all lost during the sixties when we had the violent divorce between the Defense Department and research and the universities. And I am very anxious that we find ways to put the relationship back together. It is not going to be easy. It is going to require a lot of forebearance, a lot of good will, and a lot of focus on the fact that we are all in this together.

Mr. **Nelson**. How can we help in that process of establishing good will?

Dr. **Bromley**. If I may say so, sir, one of the major problems in the whole enterprise is something—at least in the university—known as the ghost Mansfield amendment. When the Mansfield amendment was enacted in 1969, it represented the will of the people. There was no question about it. As a result of that, program officers throughout the Defense Department and all the services had their portfolios scrutinized. And if things did not have a direct and apparent relationship to an immediate Defense need, the project was dropped. Eight million dollars of projects were dropped in one bundle.

Now, the program officers also got a black eye at this point. It is not surprising that program officers treat with considerable skepticism statements made by each new Secretary of Defense, and D.D.R. & E. people who say we are now back in the business of supporting research. We are now back in the business of dealing with universities. We want to be your friends, because the program officer knows that people up there can change. And they don't want to get caught with their portfolios down again.

And, so, it seems to me that what you could do and what this committee could do and what your colleagues could do is to help to convince the people in the trenches, who actually do the support of science out there throughout the country and community that you mean business.

Mr. **Nelson**. Do any of you have a contrary expression of opinion on that subject? Do you all agree? Yes, sir.

Dr. **Basolo**. I agree but I would like to mention that a few weeks ago at Northwestern University our vice president for research and his staff got together a symposium where people from DOD were invited. And they came with the express purpose of just telling our people in the physical sciences the kinds of things that they were interested in.

Nothing classified. But their missions and so forth. Now, I think contacts have been made, so people are beginning to write proposals, particularly young people who are having difficulty in getting funding, and trying to take advantage of some of this DOD money.

Now, since I was the one that mentioned this is falling between the cracks and so forth, I don't want to be misunderstood. I am just saying that here we are spinning our wheels, thinking about waste in basic research where we keep telling you that there is none, and we have been scrutinizing this so carefully.

But when you are talking about $200 billion, I do not know enough about it, but there has got to be some waste. And if there is any waste at all, it has go to be appreciable in terms of the amount of money that is going into basic research.

So, that is the point that I was trying to make.

Mr. **Nelson**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Nelson.

I might point out that the attitude at DOD has changed considerably in the last few years. And there is a positive program going on now for fellowships and traineeships, and to renew that relationship with the universities. And I think it is a very positive step in the right direction.

Mr. Lowery.

Mr. **Lowery**. Thank you, Mr. Chairman.

Dr. Bromley, your statement included a widely held belief that corporate managers are primarily concerned with the short-term accomplishment, the immediate return on investment. If that is true, I would like to know how deeply you feel that is felt within the corporate community. How should corporate research be structured or restructured? And what changes should be made?

Dr. **Bromley**. In my testimony I quoted specifically from William Abernathy of the Harvard Business School, who made the comment recently that MBA's, one after the other, are being turned out in this country, being convinced that if they are to stay on the fast track, they have to jump corporations about every 3 or 4 years.

Once you accept that as one of your basic tenets, you are then faced with the recognition that anything you do that will pay off beyond 3 to 4 years will benefit your successor, rather than yourself, and necessarily should be viewed with a certain skepticism.

So to the extent that Abernathy is correct, and he knows a lot more about it than I do because I am from an entirely different wing of the academic business, it seems to me that we have in this country fostered a philosophy, and I think he is right, which makes it extremely difficult for any industry to really engage in long-term research. This certainly seems to be true in the sense we are discussing it here in this committee. Anything that does not pay off within something like a year or two is considered very long-range in most industries I know about.

But, I am not an expert. Some of the other people here may be able to expand this.

Mr. LOWERY. Are there any suggestions you or the other witnesses have as to what changes should be made?

Dr. BROMLEY. Our competitiveness in the international marketplace, after years of easy dominance of both national and international science, is falling, and falling rapidly. If we can't somehow convince our corporate executives and managers that in the long run our competitiveness depends on our maintaining the know-how that has brought us to where we are today, most of which has come from long-range research, then I am afraid we are going to fall from any kind of competitive position internationally.

So, if you ask me how we are going to do this, the only way I can see to do it is to somehow mount a sufficient educational campaign that will convince people that it is in the long-range best interests of the shareholders of the corporations of this country to do it, and have them force their own managements and their own people to take this somewhat longer view than seems to be the case at the moment.

Mr. LOWERY. Further comments by witnesses? Let me follow up with a question as well. The committee is continually exposed to international research comparisons. In fact, in your testimony Dr. Bromley, you mentioned the total expenditures for R. & D. in the United States is currently 2.97 percent of GNP; in Japan, 1.93 percent; in West Germany, 2.36 percent.

What really does this mean? Is there a ranking? Can we assume the funds are equally utilized or somewhat equally grouped?

Dr. BROMLEY. Let me go back and emphasize, first of all, that if we average across the board, we still have by far the strongest science and technology enterprise in the world. But by focusing their activities, one country after another abroad, Japan, Germany, Russia, you name it, by focusing on a narrow salient, are able to move up to us and ahead of us. And what is being shown in the numbers that you just quote is the fact that those salients are broadening, and they are expending more of their available resources on the long-term future of their respective countries, and on making their countries more competitive internationally, as Dr. Watson has just indicated, than we are.

They believe more than we do, it seems, that expenditures of this kind are an investment in their future. That is where the critical comparison comes. And it is a matter of national philosophy.

Dr. WATSON. I would like to come back to the very large amount of money we spend for defense. About one-half of our total R. & D. budget. This has remarkably little return to our industrial enterprise. So the amount we are doing in support of what we really need is much less than generally appreciated.

The budget for the National Science Foundation should be doubled. Then we might be getting to the point where we are really able to maintain what we have.

Dr. BROMLEY. If I may, just to emphasize Dr. Watson's point, I have the numbers here that all, the total governmental R. & D., Japan allocates 2 percent to defense, West Germany 12 percent; France 30 percent, whereas we have more than 50 percent and our fraction is growing rapidly. Those numbers speak for themselves.

Mr. **Lowery**. What is the percentage in the United States?

Dr. **Bromley**. It is between 51 and 52.

Mr. **Lowery**. Thank you very much. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Lowery.

One concluding question. It has been mentioned that probably the better thing would be to separate R from D. Is there a practical or an easy way that that can be separated, because in my opinion many times D is very related to what happened in R, and many of the same participants need to help make D work because they know all about the R.

Dr. **Bromley**. Your point is extremely well taken, Mr. Chairman. I think I have on previous occasions said that I can't tell basic from applied research, but I sure can tell good from bad research. That separation is easy, but I think what I am proposing, what I propose in my testimony today, recognizes that there is a gray area. There are certain things that are clearly all people of good will would agree are in the basic area.

Mr. **Fuqua**. And we fund programs in basic research?

Dr. **Bromley**. Yes, and also in the development area, and the criteria that should be applied to those two areas, development and research, are frequently quite different, and I think that we should focus on that aspect.

I think also that the development of priorities are quite different in the two. The time scales are quite different. The degree to which scientific judgment as opposed to political judgment should enter is quite different in the large development project on the one hand, and on the small basic research project on the other.

So I would agree with you completely, that there will always be a gray area in the middle. But I am convinced that our discussion of what our problems are in the basic research area are being clouded by the fact that for every dollar spent in basic research, 10 are spent on development. It seems development completely controls the discussion, when the perhaps more fundamental problems at any given moment may be down there in the 10 percent that is really basic research.

I would like to see the two areas considered on their merits, and I think in order to do that we really must separate them.

Mr. **Fuqua**. I see we are getting a good response.

Dr. Parry and then Dr. Leopold.

Dr. **Parry**. One of the decisions that I believe is very important in the industrial community is a guess as to whether a project will succeed or not industrially. It is very, very hard to make that as long as you are in the basic research province, and for that reason industry has been unwilling to fund basic research in the amount that the country needs.

They are more willing to fund development work, because at that point you can make a better guess as to whether it will work or not. In reference to Dr. Bromley's separation, you are more apt to have the private sector pick up some of these development operations, whereas nobody really is going to be willing to pick up the basic research operation.

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Mr. **Fuqua**. I think that is very true. Dr. Leopold.

Dr. **Leopold**. I am not sure I would agree with the separation of R. & D. It would seem to me that much is to be said for an integration of the people who have expertise in the basic side and the people whose charges are in the developmental side. I would say long live the grey area between the two.

Dr. **Bromley**. If I may, Mr. Chairman, I want to emphasize I never suggested that we separate the activities or the people or anything else, but we should separate the budgets, so that we can discuss them knowledgeably. They are two different things.

Mr. **Fuqua**. Well, we do that in many areas, particularly in, say, the National Science Foundation, which is primarily supporting basic research. Now, when we get into, say, the Department of Energy, we do have basic energy sciences, nuclear physics, and other programs, but we also have demonstration programs, which is a further refinement of development.

So we do have many programs that are broken down in those areas, but we tend to lump all those budgets when we talk about R. & D. in this country or R. & D. in some other country. Then we are talking about the whole combined figure that we use in both.

Dr. **Bromley**. Yes. If I can make one last point, sir, in this connection, and relating to our prior discussion about the Defense Department. It does bear emphasis that because the area that is growing by far the most slowly is basic research, and in the long run it may be the most important in terms of our national defense and security.

Mr. **Fuqua**. Dr. Parry.

Dr. **Parry**. I would like to comment that I don't disagree with Dr. Leopold; long live the gray area. I think that that is a basic given in the nature of research and development.

There is always going to be an overlap of these two, but ultimately when a project gets a long ways along, you begin to get additional people of a different type into the development phase, and it moves away from what had been done in the basic research area, and I think it is in that context that one can consider the transfer of funds, where industry might be willing to pick up a charge and where they would not be willing to do so in the basic research area.

Dr. **Bromley**. Yes.

The **Chairman**. I want to thank all of you for your time and having a chance to visit with you earlier today. We thank you very much for your testimony and your time and responses to the questions. I think you can see by the participation of the Members that we are all very concerned and interested in the future of our scientific program. We thank you very much for your contribution.

The committee will stand adjourned until 9:30 in the morning.

[Whereupon, at 4:40 p.m., the committee adjourned, to reconvene at 9:30 a.m., Thursday, February 4, 1981.]

U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS

THURSDAY, FEBRUARY 4, 1982

House of Representatives,
Committee on Science and Technology,
Washington, D.C.

The committee met, pursuant to call, at 10:10 a.m., in room 2318, Rayburn House Office Building, Hon. Ronnie Flippo presiding.

Mr. Flippo [presiding]. The meeting will come to order.

Mr. Fuqua is unavoidably detained for a moment. I am sure he will be joining us directly. I ask unanimous consent that Mr. Fuqua's opening remarks be placed in the record at this point.

[The prepared opening statement by Mr. Fuqua follows:]

OPENING STATEMENT
OF THE
HONORABLE DON FUQUA (D-FLA.)
AT THE HEARING ON
U.S. SCIENCE AND TECHNOLOGY UNDER BUDGET STRESS
FEBRUARY 4, 1982

MR. FUQUA: THIS MORNING'S SESSION WILL CONCLUDE THE FIRST PHASE OF OUR CONSIDERATION OF THE FY 1983 BUDGET. WHEN WE HAVE HEARD THE FOUR DISTINGUISHED WITNESSES SCHEDULED TODAY WE WILL HAVE LAID A SOUND BASE FOR THE NEXT PHASE IN WHICH OUR SUBCOMMITTEES WILL CONSIDER THE R&D BUDGETS OF THE VARIOUS AGENCIES THAT COME BEFORE US.

BY WAY OF INTRODUCTION TO TODAY'S SESSION I WANT TO MENTION TWO POINTS RELATED TO THE EXPERIENCE OF OUR WITNESSES, ALL OF WHOM ARE DISTINGUISHED UNIVERSITY PRESIDENTS. SEVERAL PREVIOUS WITNESSES HAVE REFERRED TO THE NEED FOR MORE TECHNICALLY TRAINED PEOPLE IN INDUSTRY, ESPECIALLY ENGINEERS. HOW SHOULD WE RESPOND TO THIS NEED? IS IT A REAL NEED OR MERELY A CYCLICAL PHENOMENON WHICH WILL BECOME A SURPLUS IN A FEW YEARS? SHOULD WE CONCENTRATE ON TRAINING MORE ENGINEERS OR ON A BROAD SCIENTIFIC AND TECHNICAL LITERACY? GIVEN TIGHT BUDGETS, HOW DO WE SET PRIORITIES?

SECOND, A WITNESS FROM THE ELECTRONIC INDUSTRY STATED THAT INDUSTRY NEEDS THE STOREHOUSE OF EXPERTISE THAT EXISTS IN THE UNIVERSITIES, IN ORDER TO MEET FOREIGN TECHNICAL COMPETITION. HE STATED THAT HIS INDUSTRY DID NOT WANT DIRECT FEDERAL AID, BUT WOULD LIKE TO SEE CONTINUED FEDERAL FUNDING OF UNIVERSITY RESEARCH. WHAT WILL HAPPEN TO THE EXPERTISE IN THE UNIVERSITIES IF PRESENT BUDGET TRENDS CONTINUE? WILL IMPROVED COUPLING BETWEEN INDUSTRY AND UNIVERSITIES HELP COMPENSATE FOR REDUCED R&D BUDGETS? HOW WILL THE PRESENT TRENDS AFFECT THE TRADITIONAL UNIVERSITY ROLE IN BASIC RESEARCH?

SUCH QUESTIONS WILL BE ASKED IN COMING WEEKS AS WE DEAL WITH SPECIFIC AGENCY REQUESTS. I AM SURE THAT TODAY'S TESTIMONY WILL PROVIDE A VERY HELPFUL BACKGROUND.

OUR FIRST WITNESS WILL BE DR. WALTER SMITH, PRESIDENT OF FLORIDA A&M UNIVERSITY IN TALLAHASSEE.

SECOND, WILL BE DR. EDWARD BLOUSTEIN, PRESIDENT OF RUTGERS UNIVERSITY IN NEW JERSEY.

THIRD, WILL BE DR. PETER MAGRATH, PRESIDENT OF THE UNIVERSITY OF MINNESOTA.

FINALLY, WE WILL HAVE DR. NORMAN HACKERMAN, PRESIDENT, RICE UNIVERSITY AND FORMER CHAIRMAN OF THE NATIONAL SCIENCE BOARD.

I am very pleased to welcome to this hearing, Dr. Walter Smith, President of Florida A&M University. Florida A&M is one of those traditionally black universities which played a crucial and historic role in educating black students when they were being deprived of other opportunities in higher education. Florida A&M has continued and will continue to provide special opportunities. Further, under the leadership of President Smith, it has engaged in front-rank research. Such research is vital in determining the academic health and promoting high scholarly standards in a modern university.

It was perhaps inevitable that these hearings on "Science and Technology Under Budget Stress" would bring in a diversity of issues as well as viewpoints. We have already heard sharp exchanges about the relative importance of keeping up the research levels at those universities which are acknowledged as being our very best, vis-a-vis keeping up the research activities at universities which are geographically distributed but have not as yet acquired the highest academic prestige.

As the dollars grow more scarce, such choices may have to be made. This is probably not the time to explore this issue in detail, but I thought it would be very important for us to hear from a university that is still trying to develop a program of excellence in this time of budget stress.

President Smith, I welcome you to these hearings and I want to congratulate you on the excellent job you are doing.

I understand that Mr. Flippo would also like to welcome you and make a statement for the record. Mr. Flippo.

We would like to start our hearings with a slight change. I know the chairman would like to address Dr. Smith and, Dr. Smith, with your kind agreement I would like to start with Dr. Bloustein's testimony first, if that would be acceptable, if your schedule will permit that.

I would like to ask unanimous consent of the committee for tape recordings and photographs and television during this session. Without objection, we will conduct it in that fashion.

I think the chairman, Mr. Fuqua, has been receiving the testimony of all our witnesses and then, when all testimony has been presented and then going to questions in the interest of time.

So, if it would be acceptable we would like to have your testimony at this time, Doctor. Please feel free to summarize your statement and we will include your entire statement in the record.

I might say that Mr. Roe would like to have been here to extend his welcome to you, but he could not be here.

[The biographical sketch of Dr. Bloustein follows:]

RUTGERS NEWS SERVICE
Barbara Selick Dawson, Director
Tel. (201) 932-7084

October 1981

BIOGRAPHICAL OUTLINE OF DR. EDWARD J. BLOUSTEIN, PRESIDENT OF RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY

BORN:
New York City, January 20, 1925
Son of Samuel Bloustein (deceased) and Celia (Einwohner) Bloustein (deceased)

EDUCATION:
J.D., Cornell Law School, 1959
Ph.D., in Philosophy, Cornell University, 1954
B. Phil., Oxford University, 1950 (Wadham College)
B.A., New York University, 1948 (Washington Square College)

PROFESSIONAL EXPERIENCE:
President, Rutgers, The State University of New Jersey, 1971 to present.
Member, Board of Directors, United Jersey Banks, 1972 to present.
Member, Board of Directors, Columbia Pictures Industries, Inc., 1978 to present.
President, Bennington College, 1965-1971.
Professor of Law, New York University Law School, teaching Torts and Jurisprudence, 1961-1965.
Private Law Practice, specializing in Appellate Law, New York City, 1961-1965.
Law Clerk to former Chief Judge Stanley H. Fuld of the Court of Appeals of the State of New York, 1959-1961.
Political Analyst, United States Department of State, 1951-1952, 1955-1956.
Instructor in Logic and Philosophy, Cornell University, 1954-1955.
Lecturer in Philosophy of Law and Social Philosophy, Brooklyn College, 1950-1951.
Member of the Bar, New York State, The State of Vermont.

PUBLIC SERVICE:
President, College Public Agency Council of the New York Region of the United States Civil Service Commission, 1977 to present.
Member, Commission on Individual Liberty and Personal Privacy, State of New Jersey, 1977 to present.
Chairman of Council of Presidents, and member, Executive Committee, National Association of State Universities and Land-Grant Colleges.
Chairman, Legal Affairs Committee, National Association of State Universities and Land-Grant Colleges, 1975 to present.
Special Committee on the Second Century, Bar Association of the City of New York, 1972 to present.
Member, Advisory Council, Cornell Law School, 1974 to present.
Member, Advisory Council, Department of Philosophy, Princeton University, 1973 to present.
Member, Panel on Privacy and Behavioral Research, Executive Office of the President, Office of Science and Technology, 1967. See "Privacy and Behavioral Research," a report of the Panel (1967).

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MILITARY SERVICE:

Served with the U.S. Army 1943-1946, discharged with rank of staff sergeant.

BOOKS, REPORTS AND ARTICLES:

Freedom of Expression, a book to be published in 1982.
"Social Responsibility, Public Policy, and the Law Schools," New York University Law Review, (1980).
Individual and Group Privacy, Transaction Press(1978).
"Privacy Is Dear At Any Price: A Response to Professor Posner's Economic Theory," *12 Ga. L. Rev.* 429 (1973).
"Group Privacy: The Right to Huddle," 8 *Rutgers Camden Law Journal* 219 (1976).
"The First Amendment and Privacy: The Supreme Court Justice and the Philosopher," 23 *Rutgers Law Review* 41 (1974).
The University and the Counterculture, Rutgers University Press (1972).
Dimensions of Academic Freedom, joint author, Illinois University Press (1969).
"Privacy, Tort Law and the Constitution," 46 *Texas Law Review* 611 (1968).
"The Statute of Limitations Applicable to Common Law Recovery for Radiation Injuries," a study for the Atomic Energy Commission, (1966).
Nuclear Energy, Public Policy and the Law, editor, Oceana Press (1964).
"Privacy As An Aspect of Human Dignity," 39 *New York University Law Review* 962 (1964).
"Logic and Legal Realism" 50 *Cornell Law Quarterly* 24 (1964).
"Account of a Field Study in a Rural Area of the Representation of Indigents Accused of Crime," with B.F. Willcox, 59 *Columbia Law Review* 551 (1959).
"The Griffin Case--Poverty and the Fourteenth Amendment," with B.F. Willcox, 43 *Cornell Law Quarterly* 1 (1957).
"Political Dynamics in East Germany," a study for the Office of Intelligence Research of the United States Department of State, (1956).
"The Reconstitution of the Socialist International," a study for the Office of Intelligence Research of the United States Department of State, (1951).

AWARDS AND DISTINCTIONS:

L.H.D. (hon.) Hebrew Union College, 1977
LL.D. (hon.) College of Charleston, 1976
LL.D. (hon.) University of Pennsylvania, 1975
LL.D. (hon.) New York University, 1972
LL.D. (hon.) Cedar Crest College, 1970
Editor-in-Chief, *Cornell Law Quarterly*, 1959
Fulbright Scholar at Oxford University, 1948-50
Phi Beta Kappa, 1948
"Business Statesman of the Year," Sales Executive Club of New Jersey, April, 1978

FAMILY:

He married Dr. Ruth Ellen Steinman, a pediatrician, in 1951 and they have two daughters, Elise, born December 31, 1952 and Lori, born October 17, 1954.

10/81

STATEMENT OF DR. EDWARD J. BLOUSTEIN, PRESIDENT, RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY, NEW BRUNSWICK, NEW JERSEY

Dr. BLOUSTEIN. Thank you very much, Mr. Chairman, and members of the committee.

I am Edward J. Bloustein, president of Rutgers, the State university of New Jersey, and I am pleased to join my colleagues from a number of distinguished universities this morning to contribute to this committee's hearing and review of U.S. science and technology under budget stress.

It is a subject of the greatest importance to our Nation and to our Nation's universities and I congratulate the committee on focusing so sharply on this vital issue.

The commitment of Rutgers to science and technology is fundamental. I am pleased to add as well that although we are being severely strained, our program is still sound. Moreover, let me add that however great the stress, science and technology will continue to play a central role in the university's teaching and research mission.

As I have intimated, however, we are currently facing substantial budget problems in science and technology, specifically in the areas of faculty compensation, graduate support and equipment, and facility needs which threaten our very capacity and the continued quality of our effort.

It is my overall judgment, and that of many of my colleagues throughout the country, that the maintenance of current levels of scientific and technological support will only be sufficient to maintain the status quo in our universities.

It will not enable us to recapture our once commanding lead in the international spheres and it will not enable us to help revitalize as we should, this Nation's economy and this Nation's defense preparedness.

I would like to review with this committee very briefly the role of science and technology at Rutgers and the problems facing us. I should then like to focus on the specific areas of gravest concern to us, including those areas most appropriate, in my judgment, for redress by the Federal Government.

Rutgers College, the antecedent of Rutgers, the State university was chartered in 1766 and is the eighth oldest college in the United States.

We became the land-grant college of New Jersey in 1864, the State university in 1956. I should add that we are the only colonial college that became a land-grant college and a State university.

Science and technology have played a large part in the university's mission from the earliest days of the colonial college to today's multipurpose, multicampus university which enrolls 48,000 students and has an annual operating budget of some $300 million.

Indeed, the scientific and technological interests of the university were instrumental in obtaining the land-grant status and as a State university we have emphasized science and technology at every step in our development.

I hope you will indulge me for a few moments at least while I take a moment to point with pride to certain of our accomplishments.

Our departments of physics and mathematics have both been designated as centers of excellence by the National Science Foundation.

Our microbiology efforts are based at the Waksman Institute, named for the distinguished Rutgers Nobel Prize winning faculty member Selman Waksman, who discovered streptomycin.

We have substantial work of national distinction in statistics, chemical engineering, and agriculture. Our computer science department is one of the strongest in the United States.

Our faculty has been enormously successful in competition for Federal research funds awarded under the peer review process. In fact, Federal grants have doubled in the last 5 years and we are currently very excited about the possibility of extending our cooperation with industry.

We are very enthusiastic about the recent National Science Foundation initiatives in generic research designed to foster university-industrial cooperation.

And we are proposing a very heavy investment in the area of ceramics research in our college of engineering which has both a long-range history of excellence in basic research and very strong ties to industry.

However, as this committee might realize, I am very concerned about certain tendencies which seem to threaten our current level of achievement as a center of research and science and promise to forestall necessary progressive development.

Let me describe my general concerns by focusing on four specific areas: faculty compensation, graduate student support, equipment instrumentation and facilities, and the current steady state level of Federal support of research.

In simplest terms, the problem of faculty compensation in certain areas of science and technology, particularly computer sciences and engineering, is the disparity between our salary scale and the salary scale offered by industry.

It is not uncommon for our faculty to receive salary offers from industry at a level of $20,000 a year higher than we can offer at Rutgers.

I underscore that this disparity exists despite the fact that our salary scale is among the top 5 percent in the Nation.

The problem is compounded by the fact that our ability to retain faculty depends not only on salary but also on the maintenance of an overall research environment including graduate and technical assistance, state-of-the-art instrumentation, equipment and facilities, and a reasonable level of external funding adequate to meet the high cost of research.

All of these elements of the research environment are, in my judgment, matters of Federal competence and they require the attention of the Federal Government.

A supply of quality graduate students is crucial to our mission as a research university. Successful basic research depends on quality research assistance which, in turn, requires that we prepare the personnel and processes for that assistance to continue into the indefinite future.

Thus, as we do our current research, we must train future researchers to carry on future research efforts.

We, at Rutgers, have reached a crisis stage in such areas as engineering and computer science. Industrial demand has been so severe and the rewards so great that college seniors find graduate work unattractive at the substantial expense of our graduate and research programs.

The Exxon Foundation has recently estimated that in order to attract students to graduate work, stipends must approach one-third of the level of starting industrial salaries for graduating seniors which now exceeds, $25,000. This is a salary for a graduating senior.

Generally, our stipends run $6,000. The most immediate impact of this on the university and on all universities is that we are breaking the lines of continuity in our basic research program.

We are plainly not training sufficient numbers of either current or future faculty.

Our department of computer science, for instance, has always had more faculty lines available than it can fill. And we have been forced to freeze the level of majors in that department.

The situation in engineering is equally disastrous. Nationally there is a shortage of 2,000 engineering faculty.

I take no pleasure in noting that a recent Library of Congress survey done at the request of Congressman Ike Skelton finds the Soviets training five times the number of engineering students that we are training.

I also note that the Defense Department currently estimates it has 5,000 unfilled civilian and military openings in the hard sciences and engineering.

In terms of scientific research and equipment, State funds at Rutgers allow us to replace 1 percent of our equipment a year. At a minimum, we should be replacing 10 percent of that equipment annually. We simply can't wait a century for equipment replacement.

We must rely heavily on Federal grants, student tuition and endowments to make up the crucial difference between need and State support with the Federal contribution looming much larger than any of the others.

Let me say plainly and as emphatically as I can, that without the equipment grants available in the recent past through the National Science Foundation, our equipment and instrumentation will soon fall far below the national norm, which, is estimated by the National Science Foundation and the Association of American Universities to be twice the age of equipment found in industry.

In fact, industrial leaders now regularly complain to me that they must retrain our best students to use state-of-the art equipment which students have never seen at the university level.

To turn to facilities, the picture looks equally bleak. We have a $20 million backlog of deferred maintenance and repairs.

Our animal care facilities are in compliance with relevant Federal regulations. However, we require an expenditure in excess of $4 million to meet the accreditation standards of the American Association for Accreditation of Laboratory Animal Care.

We estimate that our library, especially our science collections, our College of Engineering and such facilities as the Waksman Institute require some $50 million of investment to maintain their level of equality.

I want to assure this committee that I have, in the past, and I intend in the future to devote every resource at my disposal to the maintenance of scientific and technological activities at Rutgers.

My point is to emphasize to the committee that short of major Federal contribution in these areas, other available resources are insufficient to meet our needs. Neither State appropriations nor corporate investment in this area can begin to fulfill our needs.

We have heard much recently about the potential role of the private sector in supporting research programs at America's universities. Rutgers has had substantial experience in this area.

The work of Professor Waksman, which led to the discovery of streptomycin, was funded by Merck and Co. Current campus support ranges from the Bell Laboratories' funding of some of the costs of our nuclear research laboratories to the exciting and innovative industrial consortium that has just been formed to fund the ceramics work at our College of Engineering while serving the ceramics industry itself.

I have given highest priority to increasing private sector support at Rutgers and just established in my own office an Office of Industrial Liaison and Reserved Services. I have worked nationally with New Jersey's junior Senator, Bill Bradley, to incorporate tax credits for business support of research under the 1981 Tax Acts.

Our College of Pharmacy has industrially funded faculty positions and we are engaged in a fund-raising campaign for certain campus building additions.

This experience has been encouraging but it has also led me to understand the limits of industry's capacity to support university research.

Because of the conditions under which industry must report, quarterly and annually, a bottom line profit, they are simply not in a position to make an investment in the long-term returns of basic research.

They can only support basic research in a very limited way. Their substantial investment must necessarily be in that applied research which is nearer to the development stage and which will show up on quarterly and annual accounting bottom lines to management and shareholders

Looking at State support, I note that the State of New Jersey ranks 46th in higher education expenditures per capita, 44th in expenditures per student and 42d for population aged 18 to 24.

In a pattern somewhat common to many Northeastern States, New Jersey does not have a record of high investment in higher education, particularly in the public university segment.

The State budget at Rutgers this year is exactly what it was last year and we have made up a 10-percent inflationary difference through severe budgetary cutbacks and an 18-percent tuition increase.

I have no doubt the State of New Jersey, like so many other States, can and will do everything in its ability to fund the university. I also have no doubt that the State will face enormous demands in terms of recently added social welfare and other programs at a time of relatively high unemployment and declining revenues.

What is left over in that State appropriation bill cannot begin to maintain, no less advance, our scientific and technological enterprise.

This then leads me to the role of the Federal Government in the budget stress facing science and technology at Rutgers. As this committee is well aware, during this century the U.S. Government has become, properly, the prime investor in basic research, particularly the 80 percent of basic research done to our Nation's universities.

We have now seen some real slippage in that investment. In 1965, the United States invested 2.8 percent of its gross national product in research and development.

In 1980, the figure had dropped to 2.25 percent. During the same time, Germany increased its investment by 80 percent. In Japan, the growth has been 40 percent.

The Department of Defense estimates it has underfunded basic research by $4 billion since 1965.

In a recent statement that Department noted that America's current lead in the Stealth bomber and related radar devices is a direct result of the heavy expenditures in basic research in 1960.

That same statement notes, however, that our current weakness in submarine warfare is a direct result of a lack of basic research support in metallurgy and metal joining which were inadequately funded in the 1970's.

Gentlemen, there is a direct relationship between the support of basic research in our universities and the health of our economy and the preparedness of our national defense.

I want to emphasize that what I am referring to here is the historical decline since at least 1965 of the real level of Federal support in such areas as fellowships, research moneys and other areas vital to a sound research base needed to support American industry and American defense preparedness.

I do not wish to imply that what we are today is the result solely of the current administration or any single past administration.

It is true that the current administration's cuts in the social sciences and student financial aid as well as their general policy of level funding for current science research and nonfunding new programs have affected Rutgers.

However, as I said earlier, our Federal research funding has doubled in the last 5 years. What concerns me most is that there is no aggressive policy which will define a fair Federal share in the solution of such problems as graduate student assistance, and inadequate facilities and equipment in science and technology.

Indeed, in the area of graduate student support there is already a distinct and menacing threat.

In terms of graduate student support, I believe that administration proposals to be announced formally on February 8, 1982 will undercut the very core of our activities.

As most of you are aware, the administration has proposed to exclude graduate students from the graduate student loan program, cut college work study moneys by one-third, and end Federal funding of the NDSL program.

We have 4,033 full-time graduate students and we are the 12th largest university in terms of graduates in the Nation. About half of these students receive aid from the above three programs. About 800 recipients are in the sciences and engineering and their aid under these programs, of course, will either be sharply curtailed or eliminated.

In terms of equipment and instrumentation, I am sure that this committee is aware that last year the administration proposed a $100 million fund at the National Science Foundation. The current administration has simply removed those moneys.

In terms of facilities I would note that in the last 15 years the Federal investment in research facilities has declined from $130 to $30 million while construction costs have multiplied several times.

In terms of the level Federal research budget, I can provide you with one immediate example of the impact at Rutgers.

Our computer science department is presently applying for one of the centers for research and experimental computer grants funded through the National Science Foundation. Given the national need for manpower in computer science, some experts suggest that there should be at least 10 to 15 of these centers in the United States.

Before the recent administration cutbacks, the National Science Foundation had intended to fund four. We now learn that they will fund two.

On April 3, 1981, it was my privilege to chair a panel of university and corporate scientists and administrators who appeared for the first time in over a decade before the House Armed Services Subcommittee on Research and Development and who testified on the status of the university research base for defense.

I testified at that time that the university research base for defense preparedness was in some considerable disrepair. The national expenditure for research has decreased markedly; there is a serious shortage of trained research personnel and our research equipment and facilities are in a deplorable State of inadequacy.

As a result of that testimony, I am pleased to say, the Armed Services Committee will greatly increase its expenditures for basic research.

I hope this committee will take the same action as the Armed Services Committee.

I would, therefore, like to make the following recommendations for the committee's consideration.

First, I would urge this committee to give high priority recommendation to the maintenance of graduate and professional school students in the guaranteed student loan program as well as urge continued funding for the NDSL and the college work study programs.

Second, I would recommend this committee bolster the equipment and instrumentation portions of the National Science Foundation grants and review the need to reinstate a separate instrumentation program.

I would also encourage the committee to meet with its counterparts in such areas as Defense and Commerce to address this very serious problem.

Separate from the instrumentation and equipment issues, we also have, third, a problem in scientific research facilities.

In my judgment, the solution to that problem will involve some participation and funding by the Federal Government. I would urge this committee to review the matter in some formal manner.

I deeply appreciate, Mr. Chairman, this opportunity to appear before such a distinguished committee whose members have given such great historical support to science and technology at America's universities.

I have developed this testimony with a full understanding of the competing needs being placed on the Federal budget. But I urge this committee to remember the extraordinary value this Nation has received from its investment in research and development as a stimulation to our Nation's economy and as a provision for the national defense.

This Nation's greatness is truly tied to the developments in science and technology of the last century, particularly to the period of such development since World War II.

Your committee has served our Nation well in these developments. Please be assured of my full cooperation and support of your work now and in the future and that of my colleagues.

Let me add one final word.

I am not here personally to take any stand on national priority. I am here, however, as a professional to say, that given this administration's priority, the highest order effort should be made to fund our basic scientific and research resources in the universities of this Nation.

If defense preparedness is at the top of our need as a Nation, and if a revitalization of the economy of this Nation is second, each of those goals can only be accomplished through a revitalization of the funding of university research and technological efforts.

It was those efforts that made for our greatness as an economic power in the postwar period, and built our military preparedness. We are slipping fast.

We urge this committee most strongly to see that we don't slip further and that, indeed, we recapture our position.

Thank you very much, Mr. Chairman.

[The prepared statement of Dr. Bloustein follows:]

U.S. SCIENCE AND TECHNOLOGY: UNDER BUDGET STRESS

A PERSPECTIVE FROM RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY

Testimony by

Edward J. Bloustein
President
Rutgers, The State University of New Jersey

for the

House of Representatives Committee on Science and Technology

February 4, 1982

I am Edward J. Bloustein, President of Rutgers, The State University of New Jersey. It is my understanding that the purpose of this hearing is to review: "U. S. Science and Technology: Under Budget Stress," with presidents of a representative number of major universities.

The commitment of Rutgers to science and technology is sound, and science and technology will continue to play a central role in the University's teaching and research mission. However, I must also inform this Committee that Rutgers is facing major budget problems in science and technology, specifically in the areas of faculty compensation, graduate support, and equipment and facilities needs. It is also my judgment that, in total, the level of scientific and technology support available to the University is adequate only to maintain the status quo; it is not enough to maintain or increase our lead in international competition. A full solution to this budget stress is beyond the available resources of our students, of our endowments, of the private sector, and of state appropriations.

I should like to review with this Committee very briefly the role of science and technology at Rutgers and the problems facing us. I should then like to focus on areas of budget stress, including those areas most appropriate for redress by the Federal Government.

Rutgers College, the antecedent of Rutgers, The State University of New Jersey, was chartered on November 10, 1766 and is the eighth oldest college in the United States. We became the land-grant college of New Jersey in 1864 and the state university in 1956. Science and technology have played a large part in the University's mission from the earliest days of the colonial college to today's multi-purpose, multi-campus University which enrolls some 48,000 students. Indeed the scientific and technological interests of the University were instrumental in obtaining the land-grant status, and as a state university, we have emphasized science and technology at every step in our development.

I can point with some pride at certain extraordinary accomplishments. Our Departments of Physics and Mathematics have both been designated as Centers of Excellence by the National Science Foundation. Our microbiology efforts are based at the Waksman Institute, named for the distinguished Rutgers Nobel Prize winning faculty member, Selman Waksman, who discovered streptomycin. We have substantial work in Chemistry, Statistics, Engineering, and in the agricultural areas. Our Computer Science Department is one of the strongest in the United States. Our faculty have been enormously successful in competition for federal research funds awarded under the peer review process. In fact, federal grants have doubled in the last five years.

We are currently very excited about the possibility of extending our cooperation with industry. We view with great affirmation the recent NSF initiatives in generic research, which foster university-industrial cooperation, and we are proposing a very heavy investment in the area of ceramics research in our College of Engineering, which has both a long range history of excellence in basic research and strong ties with industry. However, as this Committee might realize, I do have some alarm about certain directions taken in the development of our university research base. These developments have led to the budget stress which most affects the profile of science and technology at New Jersey's State University. That budget stress can best be dealt with under the succinct headings of faculty compensation, graduate student support, equipment, instrumentation and facilities, and the current steady state level of federal support.

At one simple level the problem of faculty compensation in certain areas in science and technology, particularly Computer Sciences and Engineering, is one of disparity between our salary scale and the salary scale of industry, which has such heavy demands at the current time. It is not uncommon for our faculty to receive salary offers from industry at a level $20,000 per annum higher than those at Rutgers. This is a problem for New Jersey and for Rutgers to address and I am pleased to note that our salary scale still is in the top 10 percent of the Nation's colleges and universities. However, on a more complex level, the matter of faculty compensation includes elements necessary to conduct successful research. These elements include an environment which fosters free inquiry, graduate and technical assistance, up-to-date instrumentation, equipment, and facilities and a reasonable level of external funding adequate to meet the high cost of research. All of these areas, in my judgment, are matters of some federal concern.

The role of graduate students at Rutgers is crucial to its mission as a research university. Successful basic research must build on successive past efforts while preparing the personnel and processes for the work to continue into the indefinite future. Thus, we must train future researchers as we carry on current research.

In science at Rutgers, we have reached a crisis stage in such areas as Engineering and Computer Science. Industrial demand has been so severe and the rewards so great that seniors find graduate work unattractive--at the substantial expense of our graduate programs. The Exxon Foundation has recently estimated that in order to attract students to graduate work, stipends must approach one third of the level of starting industrial salaries for graduating seniors, which now exceed $25,000. Generally our stipends run $6,000. The most immediate impact of this on the University, and on all universities, is that we are breaking the lines of continuity in our basic research program and not training sufficient numbers of either current or future faculty. Our Department of Computer Science, for instance, has always had more faculty lines available than it can fill and we have been forced to freeze the level of majors in that department. The situation in Engineering is equally damaging. Nationally, there is a shortage of over 2,000 Engineering faculty. I take no pleasure in noting that a recent Library of Congress survey done at the request of Congressman Ike Skelton (Democrat-Missouri) finds the Soviets training five times our number of Engineering students. I would also note that the Defense Department currently estimates it has 5,000 unfilled civilian and military openings in the hard sciences and engineering.

In terms of scientific research and equipment, state funds at Rutgers allow us to replace about 1 percent of our equipment each year. At a minimum, we should be replacing 10 percent of that equipment, and rather than wait a century for equipment replacement, we rely heavily on federal grants, student tuition, and endowments to make up the crucial difference. I would emphasize that without the equipment grants available in the recent past through the National Science Foundation, our equipment and instrumentation will fall far below the national norm, which NSF and AAU have recently defined as twice the age of equipment found in industry. In fact, industry has recently complained that it must retrain our best students in the use of modern equipment.

In terms of facilities, we have a $20 million backlog of deferred maintenance and repairs. Our animal care facilities are in compliance with the relevant regulations; however, we require an expenditure in excess of $4 million to meet the accreditation standards of the American Association for Accreditation of Laboratory Animal Care. Our Library, our College of Engineering, and such facilities as the Waksman Institute will require perhaps $50 million in the near future.

I wish to assure this Committee that I have in the past, and I intend in the future, to devote every resource at my disposal to the maintenance of scientific and technological activities at Rutgers, but this Committee should understand the parameters and the limits of our non-federal resources.

We have heard much recently about the potential role of the private sector in supporting research programs at America's universities. Rutgers has had substantial experience in this area. The work of Professor Waksman, which led to the discovery of streptomycin, was funded by Merck and Company. Current campus support ranges from the Bell Laboratories' funding of some of the costs of our nuclear research laboratories to the exciting and innovative industrial consortium being formed to fund the ceramics work at our College of Engineering, while serving the ceramics industry.

I have given highest priority to increasing private sector support at Rutgers. I have recently established under my jurisdiction an Office of Corporate and Industrial Liaison and Research Services, and I have worked nationally with New Jersey's Junior Senator, Bill Bradley, to incorporate tax credits for business support of research under the 1981 tax acts. Our College of Pharmacy has industrially-funded faculty positions and we are engaged in a fund raising campaign for certain campus building additions.

This experience has been encouraging but it has also led me to understand the limited parameters of industry support for university research. There is simply no great interest on the part of industry in supporting basic research, and there is substantial interest in supporting that applied research which is nearer to the development stage.

Regarding the State of New Jersey, I would note that the state ranks 46th in higher education expenditures per capita, 44th in expenditures per student, and 42nd per population aged 18 to 24. When related to income, the state's spending per person 18 to 24 ranks 49th. In a pattern somewhat common to many northeastern states, New Jersey does not have a record of high investment in higher education, particularly in the public university sector.

The state budget at Rutgers this year is exactly what it was last year, and we have made up the inflationary difference through budget cutbacks and an 18 percent tuition hike. I have no doubt that the State of New Jersey, like so many other states, can and will do everything in its ability to fund the University. I also have no doubt that the state will face enormous demands in terms of recently added social welfare and other programs at a time of relatively high unemployment and declining revenues.

This then leads me to the role of the federal government in the budget stress facing science and technology at Rutgers. As this Committee is well aware, during this century the United States Government has become, properly, the prime investor in basic research, particularly the 80 percent of basic research done at our Nation's universities. We have now seen some real slippage in that investment. In 1965, the United States invested 2.8 percent of its Gross National Product in research and development. In 1980, the figure had dropped to 2.25 percent. During the same time, Germany increased its investment by 80 percent; in Japan, the growth has been 40 percent. The Department of Defense estimates it has underfunded basic research by $4 billion since 1965. In a recent statement that Department noted that America's current lead in the Stealth Bomber and related radar devices is a direct result of the heavy expenditure in basic research in 1960. That same statement notes, however, that our current weakness in submarine warfare is a direct result of a lack of basic research support in metallurgy and metal joining, which were inadequately funded in the 1970's.

I wish to emphasize that what I am referring to here is the historical decline since at least 1965 of the real level of federal support in such areas as fellowships, research monies, and other areas vital to a sound research base. I do not wish to imply that what we are today is the result solely of the current Administration. It is true that the current Administration's cuts in the social sciences, in student financial aid, and in areas such as the Office of Water Resources and Technology, as well as the general policy of level funding of current science research and the non-funding of new programs,have affected Rutgers. However, as I said earlier, our federal research funding has doubled in the last five years. What concerns me most is that there is no aggressive policy which will define a fair federal share in the solution of such problems as graduate student assistance, facilities, and equipment in science and technology. Indeed, in the area of graduate student support, there is a distinct threat.

In terms of graduate student support, I believe that Administration proposals, to be announced formally on February 8, 1982, will undercut the very core of our activities. As most of you are aware, the Administration proposed to exclude graduate students from the Guaranteed Student Loan program, cut College Work Study monies by one third, and end federal funding of the NDSL program. We have 4,033 full-time graduate students and about half of those receive aid from the above three programs. About 800 recipients are in the sciences and engineering and their aid under these programs, of course, will either be sharply curtailed or eliminated.

In terms of equipment and instrumentation, I am sure that this Committee is aware that last year the Administration proposed a $100 million fund at the National Science Foundation. The current Administration has simply removed those monies. In terms of facilities, I would note that in the last 15 years the federal investment in research facilities has declined from about $130 million to $30 million while construction costs have multiplied several times.

In terms of the steady state federal research budget, I can provide you with one immediate example of the impact at Rutgers. Our Computer Science Department is presently applying for one of the Centers for Research in Experimental Computer Grants funded through the National Science Foundation. Given the national need for manpower in Computer Science, some experts suggest that there should be 10 to 15 of these centers in the United States. Before the recent Administration cutbacks, NSF had intended to fund four; now they are funding two.

On April 3, 1981, it was my privilege to chair a panel of university and corporate scientists and administrators who appeared for the first time in over a decade before the House Armed Services Subcommittee on Research and Development, and who testified on the status of the university research base. I had stated at that time that the university research base for defense preparedness is in some considerable disrepair, that the national expenditure for research has decreased markedly, that there is a serious shortage of trained research personnel, and that our research equipment and facilities are in a deplorable state of inadequacy. As this Committee is aware, the university research base also supports our national economy.

I would, therefore, like to make the following recommendations for the Committee's consideration:

1. That every effort be made to maintain and extend our graduate student support in science and technology. I would urge this Committee to give high priority recommendation to the maintenance of graduate and professional school students in the GSL program, as well as continued funding for NDSL and the SEOG programs. I would also hope this Committee would urge the maintenance and enlargement, wherever possible, of the research-project-funded, graduate support.
2. I would recommend this Committee bolster the equipment and instrumentation portions of the NSF project support grants and review the need to reinstate a separate instrumentation program. I would also encourage the Committee to meet with its counterparts in such areas as Defense and Commerce to address this very serious problem.
3. Separate from the instrumentation and equipment issues, we do have a problem in scientific research facilities. In my judgment the solution of that problem will involve some participation and funding by the Federal Government. I would urge this Committee to review the matter in some formal manner.

I deeply appreciate the opportunity to appear before such a distinguished Committee whose members have given such great historical support to science and technology at America's universities. I have developed this testimony with a full understanding of the competing needs being placed on the federal budget, but I urge this Committee to remember the extraordinary value this Nation has received from its investment in research and development as a stimulation to our Nation's economy and as a provision for the common defense. This Nation's greatness is truly tied to the developments in science and technology of the last century, particularly the period during and since World War II. Your Committee has served well our Nation in those developments. Please be assured of my full cooperation and support of your work now and in the future.

Mr. FUQUA. Thank you very much.

Borrowing a phrase I heard at the National Prayer Breakfast this morning, let me say, "Amen, amen, amen."

I am pleased to welcome to this hearing Dr. Walter Smith, president of Florida A. & M. University. Florida A. & M. is one of those traditionally black universities which played a crucial historical role in educating black students when they were being deprived of other opportunities in higher education. Florida A. & M. has continued and will continue to provide special opportunities.

Furthermore, under the leadership of Dr. Smith it is engaged in front rank research. Such research is vital in determining the academic health and promoting high scholarly standards in a modern university.

It was perhaps inevitable that these hearings on science and technology under budget stress would bring in a diversity of issues as well as discussion of them. We have already heard over the years and in the course of these hearings about the relative importance of keeping research levels at those universities which are acknowledged as being our very best. We are also concerned about visibly keeping the research activities strong at universities which are geographically distributed but do not have or have not as yet acquired the highest academic prestige.

As the dollars grow more scarce some choices may have to be made. This is probably not the time to explore this issue in detail but I thought it would be very important for us to hear from a university that is still trying to develop a program of excellence in this time of budget stress.

President Smith, I am very happy to welcome you. I notice in the audience, and I will deviate from protocol and say that you are accompanied by two very fine young people that came up here to make sure you stay on the right track, your daughter and son, who are very fine students themselves.

I want to welcome you to the hearings and congratulate you on doing a very fine job. I understand that Mr. Flippo, who has been most interested in this subject has a statement to make for the record.

Mr. **Flippo**. Thank you, Mr. Chairman.

President Smith, I should like to join the chairman in welcoming you.

As you know, I come from Alabama, a State which shares a border and also many aspirations with your State of Florida.

The chairman has referred to testimony we have received concerning the setting of priorities in the use of the declining Federal funds that will be available for the support of science and technology. In particular, we have heard testimony by Dr. Keyworth, Dr. Press, and Dr. Saxon that the elite schools must be protected as we react to the budget stress.

It may be rash for me to argue with this impressive array of academic wisdom, but I must say that I do not regard this as a closed issue.

It is a matter of statistical fact that most of our students are not educated in the so-called elite universities; they are educated in schools like Florida A. & M. and the University of Alabama. For that reason it seems to me to be of crucial concern that the academic quality be maintained at those universities that have not achieved that special prestige. Support for research at these universities undergirds the quality of instruction, in part because the schools do not have a long history of front-rank scholarship.

I will not argue that Federal money should be distributed mindlessly on a strictly geographic basis. But I do think it is wrong to ignore the needs of the students around the country at the places where they are being educated. What I am looking for is a geographic distribution of academic excellence rather than geographic distribution of funding.

I submit that it may even be true that a relatively minor cutback in the funding for those schools that are getting major funding now could have a salutory effect. That would be consistent with the views that Dr. Keyworth has expressed. But, I believe that withdrawing the small amount that the nonelitist colleges and universities receive would have devastating effects on them and on the quality of education that such schools offer.

I agree with Dr. Carl Leopold who testified yesterday that:

> The concentration of funding in the most prestigious laboratories can seriously impede the development of younger staff and can interfere with the flow of student training in the smaller or less notable universities.

So, President Smith, I would join with the chairman in extending to you a hearty welcome and look forward to your testimony.

[The prepared statement of Mr. Flippo follows:]

Welcoming Statement of Hon. Ronnie Flippo (D-Ala.)

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I agree with Dr. Carl Leopold who testified yesterday that "The concentration of funding in the most prestigious laboratories can seriously impede the development of younger staff and can interfere with the flow of student training in the smaller or less notable universities."

STATEMENT OF DR. WALTER L. SMITH, PRESIDENT, FLORIDA AGRICULTURAL AND MECHANICAL UNIVERSITY, TALLAHASSEE, FLORIDA

Dr. SMITH. Mr. Chairman, members of the Committee on Science and Technology, thank you for the opportunity to appear before you here today.

The discussion of U.S. science and technology under budget stress offers a unique opportunity for me to share with you some of my observations on this subject.

Further, it provides for meaningful dialog to be established between this committee and institutions of higher learning where a great deal of the Government's research and development take place.

I note with interest the several comments of previous testimonies on the subject and am not surprised that the various agency heads, particularly representatives of the current national administration espouse a stronger involvement of business and industry in the R. & D. effort. Unfortunately, however, the proponents also advocate a simultaneous withdrawal of substantial U.S. support from the scientific and technical effort.

As is true throughout many testimonies on our national scene, defense spending appears to be the one area where R. & D. will not suffer. Certainly, no one argues against the developmnt of strong defensive and offensive weaponry systems.

However, other key areas of national interest must be maintained at a healthy and viable level.

The question is: How greatly will these programs at our institutions, colleges, and universities across the country be impaired by the projected cutbacks as proposed by the current administration?

The institution I represent is a small, majority black, land-grant university where major scientific research projects are ongoing in three of our eight schools and colleges.

These efforts are supported with grants from the National Aeronautics and Space Administration, National Institutes of Health, National Cancer Center, Department of Education, the Office of Naval Research, the National Science Foundation and the Department of Health and Human Services.

Research programs developed and conducted by our school of pharmacy have been featured in a variety of national publications and the British Medical Journal.

The research scientists are involved in a wide array of projects which have regional, national, and international implications. Probably the most interesting and far-reaching efforts are relevant to air travel, space flight, and health related topics in the field of pharmacology and toxicology.

It is likely that the most recent research of note, reported by our institution, appeared in the October 1981 edition of Research Resources Reporter from NIH.

The discovery was the synthesis of a new set of anti-inflammatory steroids which, when given to laboratory animals have the same beneficial effects of steroids presently used, but without the resulting toxic side effects.

Other research at Florida A. & M. University relative to steroid synthesis includes arthritis treatment and other inflammatory conditions. Nearly 3 percent of all Americans suffer from arthritis. We are developing medications that could substantially reduce the pain and suffering associated with such diseases.

A recent report indicated at least one commercial airline carried over 38 million passengers annually. In 1980 over 296 million persons traveled on commercial airlines with the United States. Hence, important ongoing research at FAMU is exploring methods of reducing fatal and near-fatal air mishaps.

Our efforts in conjunction with NASA have been in the areas of circadian rhythms, hypertension and stress. These programs have great implications for national and international efforts in space exploration and our developing programs for safety in air travel as it relates to the work assignments of pilots and flight attendants.

In advocating the need for such research in 1980, Congressmen Royer, McClosky, and Goldwater felt the need to have scientists study the effect that jet lag has on the performance of airline pilots.

Representative Royer stated that

> Pilots will not be the only beneficiaries of the NASA research; this work on fatigue and circadian rhythms could be of significant benefit to truck drivers and workers assigned to the night shift, including doctors and nurses and nuclear power plant operators.

The interdisciplinary relationship between our behavioral and natural scientists deserves to be mentioned here. A critical biomedical research program designed to research cognitive styles, subjective feelings, and autonomic responses to stress events in the lives of college students is underway.

The importance of such an interdisciplinary research approach is underscored by the fact that stress represents one of the most vaguely understood concepts in our Nation. Yet, it is one which may have devastating effects on the human body, for example, ulcer production, coronary heart disease, and a variety of neurotic behavior patterns.

Stress is a condition which adversely affects one out of every four black Americans. Hence, the need for such research in order to enhance the quality of life for a signficant part of our American population.

In FAMU's College of Science and Technology, 43 research and teaching faculty are involved in federally funded research and development activities.

These investigators provide influential exposure and invaluable direct research experiences for hundreds of graduate and undergraduate minority students.

Actual reductions in the relatively small ($800,000) research funding base would all but eliminate this very beneficial effect and more importantly, halt the progress toward nationally useful research findings in the general areas of enzyme metabolism, anticancer agent identification, estuarian food production, astronautical blood conditions, deutron induced nuclear reactions and computer applications in chemical physics.

The fact that a small historically black institution makes such efficient use of Federal research and development dollars should be duly noted. In addition, an important national resource, our youth, have advanced into the mainstream of research activities because of our efforts to involve them at an early age.

The cutbacks as presently projected would take approximately $350,000 to $375,000 from our meager budget over the next 4 years.

Delayed funding or discontinuance of viable research programs places a severe salary strain on the very meager amount of earned overhead dollars in our budget.

Reallocation of academic manpower to teaching or other research activities becomes impossible as the fiscal year and the academic year are not congruent.

The development and delivery of technological instructional programs can be virtually stymied by Federal policy changes that shift manpower needs, deemphasizing energy conservation research, and environmental control efforts.

Development of the very significant pool of scientific and technical talent in our youth is an effort which deserves priority consideration for direct Federal support.

Insufficient junior and senior high school preparation in mathematics and the sciences will lead to a serious and alarming decrease in future scientists.

Priority programs must be designed to increase preparation in the sciences at the elementary and secondary school level. Minority youth offers an untapped source of scientific expertise.

Specific training programs designed to concentrate minority youth on technical subjects have markedly increased comprehension of those disciplines.

The level of funding required for significant results is relatively low as compared to the potential discoveries and cures made by the scientists derived from these programs.

The scientific and technological problems that must be resolved in order to eradicate world hunger are also deserving of direct Federal support. The breadth of these problems exceed those efforts normally made to improve farm operations. They include research in food preservation and storage, basic and child nutrition, identification and production of new food sources, and transportation.

The United States must take the leadership role in these research areas, the transfer of new technologies and the training of scientists from developing countries are essential.

The need for quality, high level research activities has been documented by the advancements the United States has made in space, computer technology, medicine, and numerous other areas.

As we begin the next century, it will be necessary for this country to maintain this leadership role in science, and technology. Through research at the colleges and universities across the country, scientific research and training has facilitated the advancement of knowledge and the improvement of life for the people of this Nation and the world.

Through various Federal programs, research at minority institutions in the areas of health care, science and technology has significantly increased. Even though research and training programs have expanded, the representation of minorities at the Ph. D. level in the natural sciences is still less than 1 percent nationally.

Research and training activities at Florida A. & M. University and other minority institutions has enabled minority scientists to reach the mainstream of research activity and make significant contributions in various fields of endeavor.

Mr. Chairman, in review of the literature one will find that the NSF spent $17 to $18 million to attract minorities and women to scientific and technical education last year.

There must be a continuation of this effort in order to improve this Nation's minority involvement in the scientific and technical fields.

A great emphasis is being placed on the use of business and industry as major boosters of our R. & D. efforts. This concept is wholesome.

However, we must remember that private enterprise works to produce a profit as quickly as possible and to the satisfaction of stockholders.

Our national and international interests must not be left to this approach.

Government should maintain its present thrust in science and technology, including enhancement of ongoing quality programs, toward impoving the status of our Nation in the world marketplace for the improvement of health care, the solution of world hunger, the enhancement of space exploration, the improvement of our national defense and the reestablishment of our Nation as the world leader in scientific and technological development.

Toward this end we must not lose our greatest natural resource, our youth. They must be oriented toward the hard sciences and mathematics, research and development, as well as a sensitivity to national and international happenings and priorities.

Yesterday, February 3, 1982, the Washington Post, on its editorial page provided some interesting commentary. The editor suggested that our scientific pre-eminence is under strain. The editor further suggested that the problem is in our education system beginning in our secondary schools curriculum in science and math.

Moreover, states the editor, basic research as a long-range investment for the benefit of all society is properly and necessarily the responsibility of the Federal Government. On this I concur.

America must not be awakened to the shock of another nation having surpassed our research and development accomplishment as was the case on October 1957. On that day none of us knew exactly what the launch of Sputnik I meant to the world of technological development.

Our Government scrambled to establish new programs, many agencies, and pumped billions of dollars into a catch-up effort.

Finally, Comdr. Alan Shepard rode a Mercury rocket into a suborbital flight from Cape Kennedy, hence the beginning of the United States real acceleration into the space race.

Today, the race for space superiority is no longer the question. The real question is how can America maximally utilize its full human and financial resources to maintain its world status for the benefit of all its people through meaningful scientific and technological advancement.

I recently received from the Ames Research Center in Moffett Field, Calif. a letter from Dr. C. M. Winget, one of your research scientists at NASA which applauded the efforts and research of Florida A. & M. University. I quote:

> The overall research productivity of the School of Pharmacy is certainly in the upper percentiles. This is especially impressive if one considers some of the other factors, such as minimal lab assistance, excessive faculty work load impinging on the research professor.
>
> This high level of productivity is possible because the faculty in general is young and vigorous. There is good balance between the applied scientists and basic scientists.
>
> The morale is good and the faulty works very hard. The students and faculty alike respect the dean. His effective leadership is certainly a significant factor in the school's performance.
>
> Furthermore, the institution does use, to its maximum advantage, the university setting, faculty and students participate in a broad spectrum of research studies. Local health care facilities for the mentally ill person and geriatric are also utilized for research as well as teaching by the School of Pharmacy.

It goes on to state that the greatest need for Florida A. & M. University is strengthening of its research facilities.

In summary, Mr. Chairman, any cutbacks in our scientific and technical areas which negatively impact our efforts in quality research at the college and universities of our Nation, or which impede our efforts to introduce minorities and other youth to research and development efforts will certainly assure the Nation of an uncertain and uncomfortable future in the ongoing battle for world pre-eminence in scientific research and development.

I welcome questions and appreciate the opportunity to address your committee. Thank you.

[The prepared statement of Dr. Smith follows:]

PREPARED STATEMENT OF DR. SMITH

Mr. Chairman, members of the Committee on Science and Technology, thank you for the opportunity to appear before you today.

The discussion of U.S. Science and Technology under budget stress offers a unique opportunity for me to share with you some of my observations on this subject. Further, it provides for meaningful dialogue to be established between this committee and institutions of higher learning where a great deal of the government's research and development take place.

I note with interest the several comments of previous testimonies on the subject and am not surprised that the various agency heads, particularly representatives of the current national administration espouse a stronger involvement of business and industry in the R & D effort. Unfortunately, however, the proponents also advocate a simultaneous withdrawal of substantial U.S. support from the scientific and technical effort.

As is true throughout many testimonies on our national scene, defense spending appears to be the one area where R & D will not suffer. Certainly, no one argues against the development of strong defensive and offensive weaponry systems. However, other key areas of national interest must be maintained at a healthy and viable level.

The question is: how greatly will these programs at our institutions, colleges and universities across the country be impaired by the projected cutbacks as proposed by the current administration? The institution I represent is a small, majority black, land-grant university where major scientific research projects are on-going in three of our eight schools and colleges. These efforts are supported with grants from the National Aeronautics and Space Administration, National Institutes of Health, National Cancer Center, Department of Education, the Office of Naval Research, the National Science Foundation and the Department of Health and Human Services.

Research programs developed and conducted by our School of Pharmacy have been featured in a variety of national publications and the British Medical Journal. The research scientists are involved in a wide array of projects which have regional, national and international implications. Probably the most interesting and far reaching efforts are relevant to air travel, space flight and health related topics in the field of pharmacology and toxicology. It is likely that the most recent research of note, reported by our institution, appeared in the October 1981 edition of Research Resources Reporter, from NIH. The discovery was the synthesis of a new set of anti-inflammatory steroids which, when given to laboratory animals have the same beneficial effects of steroids presently used, but without the resulting toxic side effects.

Other research at Florida A&M University relative to steroid synthesis includes arthritis treatment and other inflammatory conditions. Nearly 3 percent of all Americans suffer from arthritis. We are developing medications that could substantially reduce the pain and suffering associated with such diseases.

A recent report indicated at least one commercial airline carried over 38 million passengers annually. Therefore, on-going research of ours is exploring methods of reducing fatal and near-fatal air mishaps.

Our efforts in conjunction with NASA have been in the areas of circadian rhythms, hypertension and stress. These programs have great implications for national and international efforts in space exploration and our developing programs for safety in air travel as it relates to the work assignments of pilots and flight attendants. In advocating the need for such research in 1980, Congressmen Royer, McClosky and Goldwater felt the need to have scientists study the effect that jet lag has on the performance of airline pilots. Representative Royer stated that "pilots will not be the only beneficiaries of the NASA research; this work on fatigue and circadian rhythms could be of significant benefit to truck drivers and workers assigned to the night shift, including doctors and nurses and nuclear power plant operators."

In FAMU's College of Science and Technology, forty-three (43) research and teaching faculty are involved in federally funded research and development activities. These investigators provide influential exposure and invaluable direct research experiences for hundreds of graduate and undergraduate minority students. Actual reductions in the relatively small ($800,000) research funding base would all but eliminate this very beneficial effect and more importantly, halt the progress toward nationally useful research findings in the general areas of enzyme metabolism, anticancer agent identification, estuarian food production, astronautical blood conditions, deutron induced nuclear reactions and computer applications in chemical physics. The fact that a small historically black institution makes such efficient use of federal research and development dollars should be duly noted. In addition, an important national resource, our youth, have advanced into the mainstream of research activities.

Delayed funding or discontinuance of viable research programs places a severe salary strain on the very meager amount of earned overhead dollars in our budget. Reallocation of academic manpower to teaching or other research activities becomes impossible as the fiscal year and the academic year are not congruent. The development and delivery of technological instructional programs can be virtually stymied by federal policy changes that shift manpower needs, de-emphasizing energy conservation research and environmental control efforts.

Development of the very significant pool of scientific and technical talent in our youth is an effort which deserves priority consideration for direct federal support. Insufficient junior and senior high school preparation in mathematics and the sciences will lead to a serious and alarming decrease in future scientists. Priority programs must be designed to increase preparation in the sciences at the elementary and secondary school level. Minority youth offers an untapped source of scientific expertise. Specific training programs designed to concentrate minority youth on technical subjects have markedly increased comprehension of those disciplines. The level of funding required for significant results is relatively low as compared to the potential discoveries and cures made by the scientists derived from these programs.

The scientific and technological problems that must be resolved in order to eradicate world hunger are also deserving of direct federal support. The breadth of these problems exceed those efforts normally made to improve farm operations. They include research in food preservation and storage, basic and child nutrition, identification and production of new food sources and transportation. The U.S. must take the leadership role in these research areas, the transfer of new technologies and the training of scientists from developing countries are essential.

The need for quality, high level research activities has been documented by the advancements the U.S. has made in space, computer technology, medicine, and numerous other areas. As we begin the next century, it will be necessary for this country to maintain this leadership role in science and technology. Through research at the colleges and universities across the country, scientific research and training has facilitated the advancement of knowledge and the improvement of life for the people of this nation and the world.

Through various federal programs, research at minority institutions in the areas of health care, science and technology has significantly increase. Even though research and training programs have expanded, the representation of minorities at the Ph.D. level in the natural sciences is still less than one percent nationally. Research and training activities at Florida A&M University and other minority institutions has enabled minority scientists to reach the mainstream of research activity and make significant contributions in various fields of endeavor.

Mr. Chairman, in review of the literature one will find that the NSF spent $17 to $18 million dollars to attract minorities and women to scientific and technical education last year. There must be a continuation of this effort in order to improve this nation's minority involvement in the scientific and technical fields.

A great emphasis is being placed on the use of business and industry as major boosters of our R & D efforts. This concept is wholesome. However, we must remember that private enterprise works to produce a profit as quickly as possible and to the satisfaction of stockholders. Our national and international interests must not be left to this approach. Government should maintain its present thrust in science and technology, including enhancement of on-going quality programs, toward improving the status of our nation in the world marketplace for the improvement of health care, the solution of world hunger, the enhancement of space exploration, the improvement of our national defense and the reestablishment of our nation as the world leader in scientific and technological development.

Toward this end we must not lose our greatest natural resource, our youth. They must be oriented toward the hard sciences and mathematics, research and development as well as a sensitivity to national and international happenings and priorities.

America must not be awakened to the shock of another nation having surpassed our research and development accomplishment as was the case in October 1957. On that day none of us knew exactly what the launch of Sputnik I meant to the world of technological development. Our government scrambled to establish new programs, many agencies and pumped billions of dollars into a catch up effort. Finally, Commander Alan Shepard rode a Mercury rocket into a sub-orbital flight from Cape Kennedy, hence the beginning of the U.S.' real acceleration into the space race. Today, the race for space superiority is no longer the question. The real question is how can America maximally utilize its full human and financial resources to maintain its world status for the benefit of all its people through meaningful scientific and technological advancement.

Mr. Fuqua. Thank you very much, doctor, for a very excellent statement. I am going to have to ask Congressman Flippo to take over the committee. We have a matter that affects our committee very seriously before another committee. That is our budget for the coming year.

I am sure college presidents don't understand that but it has reached the point of a high priority at this moment and Mr. Winn and I must excuse ourselves and go present our budget before the House Administration Committee.

I want to thank all of our witnesses, those that have testified and those that have yet to testify. I hope we can get back before the questions conclude.

Mr. **Flippo** [presiding]. Thank you.

I believe our next witness is Dr. Peter Magrath from the great State of Minnesota.

Mr. **Weber**. If I can extend a greeting. I am probably going to have to leave before the questioning begins but I would like to welcome Dr. Magrath, too, particularly given the financial problems Minnesota is facing, I assume that you arrived here by Greyhound rather than airplane?

Dr. **Magrath**. Dogsled.

Mr. **Weber**. Well, at least we had plenty of snow to get you here.

Since I won't be here for the questioning I want to commend you for your handling of the university. I realize all of education is under great, great stress. Certainly Minnesota has to be under a great stress as anybody in the last couple of years and I look forward to your testimony. And I want to thank you in advance for the job you are doing there and I hope we don't complicate your life too much in the next 2 months.

Mr. **Flippo**. Please feel free to summarize and we will include the entire statement in the record.

STATEMENT OF DR. C. PETER MAGRATH, PRESIDENT, UNIVERSITY OF MINNESOTA, MINNEPOLIS, MINNESOTA

Mr. **Magrath**. Thank you very much, Mr. Chairman.

I do appreciate very much Congressman Weber's comment and greeting and I want to tell him that I personally, and the university appreciate the support he gives the University of Minnesota. And the support we consistently receive from our congressional delegation is important and it means a great deal to our State and to education.

Mr. Chairman, members of the committee, my name is Peter Magrath. I am privileged to serve as president of the University of Minnesota and I am now in my eighth year there, arriving at a time when we were recovering from the turmoil of the Vietnam era.

I am pleased to testify at this hearing and I sincerely commend the committee for the attention it is giving to those important issues that you have been studying during this week and that you have in the very recent past. Because, at no time in my memory, including the national trauma of Sputnik, has there been a greater need for reasoned discussion of the state of American science.

It is tempting to wish that we could get the public and our media to give the same kind of attention to a state of the science address as is given to the state of the Union address, but apparently that is not possible. But I fear that is such a message were given it would not be an upbeat message.

Now, this may seem peculiar to say at a time when some very extraordinarily good television programs and increasingly sophisticated publications on the wonders of science and technology have been prepared for the general public. But the fact is that these presentations are heralding research and development that is several years old.

We are bragging about our past in science and technology while our present and particularly our future is in serious doubt.

We are now beginning, then, in part to this committee, certainly to see some public discussion of our research investments in comparison with Germany, Japan, and the Soviet Union.

But I think it is fair to say that the warnings have not sunk in yet and it is up to political and educational leaders to make and justify some crucial investment decisions.

Late last summer I had the opportunity to see firsthand what can happen when a nation's investment in scientific minds and research efforts are subverted. My university has developed, as have a few other American universities, some quite substantial educational exchange activities with institutions in the People's Republic of China. And I visited the PRC last summer.

Prior to that trip I had, of course, heard about the effects of the so-called cultural revolution on science, education and the arts. But I assure you in the words of the popular expression, you have to have been there. That culture in China which was once preeminent in terms of science when our own Western culture had no science, they virtually destroyed, in China, a full generation of education and science.

Now, to be sure, according to their political values at the time, the PRC accomplished some surprising social changes in the past few decades. Their science, however, became a disaster area, and for years they failed even to keep up with other scientific activities around the world.

Now, they finally began to recognize the mistakes that has been made, though. That is the key point. My fear is that in our country our national and State budget problems and all the political flak, frankly, that you and others in leadership positions have to take because of this could lead our country, America, into a quieter form of cultural revolution where scholars and scientists get the short end because they speak with quiet voices.

The university that I serve is one of the largest in the country with 56,000 students in day classes and many more in extension programs.

Minnesota is probably about as comprehensive a university as you can find anywhere in the world and we are consistently within the top 10 universities in Federal funding.

We also raise more private money than any public university in the United States. And I can't sit here this moment in early February and tell you specific horror stories about the effects of Federal budget cuts, at least not in total numbers. Of course, we have had any number of specific programs that have been cut back and I share, profoundly, the concerns that President Bloustein expressed about graduate education and student aid support as I think does the entire education community.

In total dollars, at my university we have continued to have modest increases that almost, but not quite, keep up with inflation.

My problem is that I have learned to become paranoid about the Federal budget for academic science. I remember a bumper sticker, by the way, that I once said if you are not paranoid, you are crazy.

I think that some paranoia is justified because there is some extraordinarily disturbing evidence.

The 1982 budget, I think we must recognize, turned out to be relatively protective of many Federal research programs but I am not very hopeful about some of the proposals that are out on the table and that are coming forth in fiscal 1983.

My guess is that everyone in this room today knows most of the serious problems that are facing American universities. We are having major problems attracting and retaining the best young minds in many fields.

We are facing substantial shortages of engineering graduates in most fields. Our facilities and equipment, I assure you, are becoming obsolete and second rate and wearing out at an alarming rate.

We know that basic research is fundamental to applied research and to advanced training and we know that these effects have enormous payoffs.

But we also know that the Federal Government has a budget problem.

The most frustrating point is the fact that the budget problem by itself virtually overrules all the rest of what we know.

With the exception of the defense budget and this is true across the entire spectrum of the Federal budget, we are not given much chance to debate the merits. The bottom line rules regardless.

Few people really wish to argue the benefits of research. That has been my observation and I suspect yours. The budget constraints, though, are accepted as indisputable and much of the debate turns then to possiblities of other sources of funds, primarily industrial and yet to be defined shifts of State responsibilities.

I mentioned earlier, Minnesota already receives good support from the private sector, both nationally and within our own State of Minnesota, in that regard particularly from our high technology companies.

But in terms of increased State support, at least in my State of Minnesota, and I believe this applies, if not to all States in the Union, to many of them, to most of them, certainly New Jersey, certainly California, certainly Wisconsin.

In terms of increased State support for academic support, don't count on it. It is not going to happen. It is not going to happen in Minnesota.

I have confronted budget reductions for every one of the last 2 to 3 years and right now I am dealing with absolute base, not funny money, not projected increases, I am talking about base reductions of over $34 million in the next 17 months.

I have been through budget cuts and I know it is supposed to be good for the academic soul and my soul is in beautiful shape right now, I can tell you that.

We are lean and we are dismantling programs and services that my State is going to regret losing after it is too late.

Now, that is happening in an extremely progressive and forward-thinking State where support for research is not a partisan issue. It is a general civic commitment, a State that has traditionaly supported research.

In the health sciences our legislators have been proud of Minnesota's leadership role and they have taken actions to sustain and develop that leadership.

Most recently we have made some quite speculative investments in energy research, some of the most exciting research into alternative energy sources and the emergence of the University of Minnesota in the field of Earth sheltered and underground space utilization. But the State of Minnesota cannot do much more.

One important point that is often overlooked in discussions of who can and should pay for research investments is the absolute need to avoid the fragmentation of the research enterprise.

Our country has had and has to maintain a broad multidisciplinary research program. There has to be much involvement by many kinds of universities as we have heard this morning. But there has to be also maximum communication and cooperation among all of the researchers.

If you shift research sponsorship from the Federal Government to the private sector and the State governments, it is almost inevitably going to lead to an overemphasis on immediate applied research, research that has immediate economic development implications and you are very likely to have less communication among the Nation's researchers.

The Federal Government has a national responsibility and has developed a proper role that minimizes these problems and I strongly believe this must be maintained.

Even at the Federal level, however, we have seen an increasing tendency to support the quick and dramatic technological fix, the quick technological project. Research in social sciences, the behavioral sciences and the humanities has been taking it on the chin lately.

I know that these are the areas where you, and I assure you I, too, for my responsibility, get the flak from constituents who wonder why in the world are their tax dollars, whether it is in the State of Minnesota tax dollars or Federal tax dollars or, for that matter, private money, why are they being spent for projects that they think are flaky?

Well, I have a rejoinder. I would suggest that you consider it. Ask those critics and ask those constituents who raise legitimate questions to think of major American problems that are mainly attributable to a lack of knowledge in hard science and technology. Now there are some. I would suggst perhaps environmental pollution, energy sources and to some extent productivity.

Then list some of the other problems that we have all been trying to grapple with lately and see what kinds of knowledge we have really been lacking. Now, we have invested billions of dollars in the problems of urban America.

The principal problem is that we have virtually no knowledge base. We do not know and we have not known much more than gut level, subjective impressions of the problems and the solutions.

Not long ago we got ourselves involved in a disastrous war in Southeast Asia and it certainly was not a lack of hard science that kept us or got us into that mess. Our ignorance in the social science did.

We are now watching huge investments in military hard science, and I am not necessarily opposed to that, I want you to understand.

At the same time we are struggling to keep an already inadequate budget for international education efforts that just might eliminate or reduce the need for all of that hardware.

We are trying, I think, and hope to restore the importance of the family, improve education and enhance the quality of life and yet we know precious little beyond the commonsense that happens to be popular at the moment.

We all talk about Japanese productivity and how wonderful that is but we have precious little hard information and a popular psychology book becomes a bestseller on that subject.

Finally, the entire Federal budget issue hangs on an economic theory and potential public responses to it. Even those most directly identified with it candidly admit that we know very little from economic or behavioral research and the characterization of it as a riverboat gamble has it summed up well. But we don't even know enough to understand the odds.

Mr. Chairman, this country, as a nation, needs research and it needs healthy research universities. We can afford it because we cannot afford not to have it.

Legislative leaders have known this and have been willing to stick their necks out when research spending obviously did not command the public's attention and active support.

Educators in my institution and across the country have become far more aggressive in communicating and responding to the values of research to the general public.

I hope we can all continue these efforts because if it works out that America loses its scientific strength, our constituents will be unforgiving and they will be right to be so.

We are dealing with a fundamental national priority question here. We have had a science system that has paid off and it worked and it must not be dismantled. It must be maintained.

Mr. Chairman, members of the committee, thank you very much for listening to me.

[The prepared statement of Dr. Magrath follows:]

Testimony of C. Peter Magrath, President of the University of Minnesota
to the
Committee on Science and Technology
U. S. House of Representatives

February 4, 1982

Chairman Fuqua, members of the committee, my name is Peter Magrath, and I am the President of the University of Minnesota. I am now in my eighth year at Minnesota, arriving at a time when we were recovering from the turmoil of the Vietnam era, and those are already looking like the good old days.

I was most pleased to be invited to testify at this hearing, and I commend you for holding this week's series of hearings. At no time in my memory, including the national trauma of Sputnik, has there been a greater need for reasoned discussion of the state of American science. It is tempting to wish that we could get the public and media attention for a "State of Our Science" address as is given to the State of the Union address, but I fear that it would be far from an up-beat message. This may sound strange at a time when extraordinarily good television programs and increasingly well-developed publications on the wonders of science and technology have been produced for the general public, but the blunt fact is that these presentations are heralding research and development that is several years old. We are bragging about our past in science and technology, while our present and future is in serious doubt. We are just beginning to see public discussion of our research investments in comparison with Germany, Japan, and the Soviet Union, but I think it is fair to say that the warnings have not yet sunk in, and it is up to political and educational leaders to make and justify some crucial investment decisions.

Last summer I had the opportunity to see firsthand what can happen when a nation's investments in scientific minds and research efforts are subverted. The University of Minnesota has developed very substantial educational exchange activities with institutions in the People's Republic of China, and I visited the PRC last summer. Prior to that trip, I had heard, of course, about the effects of the Cultural Revolution on science, education, and the arts, but I assure you, in the words of the popular expression, "you have to have been there." That culture, once pre-eminent in science when Western culture had no science, virtually destroyed a full generation of education and science. To be sure, according to their values at the time, the PRC accomplished a number of surprising social changes over the last few decades. Their science, however, was a disaster area, and for years they failed even to keep up with other scientific activities around the world. They finally recognized what mistakes they had made, though, and that is the key point. My fear is that our national and state budget problems -- and all the political flak you have to take because of them -- could lead America into a quieter form of cultural revolution where scholars and scientists get the short end because they speak with quiet voices.

The university I serve is one of the largest in the country, with 56,000 students in day classes and many more in extension programs. Minnesota is probably as comprehensive a university as you can find anywhere in the world, and we are consistently within the top ten universities in federal funding. We also raise more private money than any public university in the United States. At this moment, I cannot sit here and tell you horror stories about the effects of federal budget cuts -- at least not in the total numbers. Of course we have had any number of specific programs cut back, but in total dollars, we continue to have modest increases that almost -- but not quite -- keep up with inflation.

My problem is that I have learned to become paranoid about the federal budget for academic science, and there is growing evidence that we paranoids may be right at that. The 1982 budget, I recognize fully, turned out to be relatively protective of many federal research programs, but I am not at all sanguine about proposals coming forth for FY 83.

My guess is that everyone in this room today knows most of the serious problems facing our research universities:

-- We are having major problems attracting and retaining the best young minds in many fields.

-- We are facing very substantial shortages of engineering graduates in most fields.

-- Our facilities and equipment are becoming obsolete and wearing out at an alarming rate.

-- We know that basic research is fundamental to applied research and advanced training, and we know that these efforts have enormous pay-offs, but we also know that the federal government has a budget problem.

The most frustrating point is the fact that the budget problem, by itself, virtually overrules all the rest of what we know. With the exception of the defense budget, this is true across the entire spectrum of the federal budget. We are not given much chance to debate the merits; the bottom line rules regardless. Few wish to argue the benefits of research. The budget constraints are accepted as indisputable, and much of the debate has turned to the possibilities of other sources of funds, principally industrial support and yet-to-be-defined shifts to state responsibilities.

As I mentioned earlier, Minnesota is already receiving good support from the private sector, and that has been increasing, especially from the high technology companies. The tax incentives you approved last year will help, but only modestly, and we badly need further incentives that could be accomplished with an amendment to exempt corporate support of university research from the rolling base used to calculate tax credits. Research universities are trying to get that amendment passed this year, and I urge you to give it your support.

In terms of increased state support for academic support, please do not count on it. In our part of the country, at least, that simply won't happen. I am currently confronted with budget reductions of over $34 million in the next seventeen months. We went through the budget cuts that are supposed to be good for our academic souls several years ago. We are plenty lean right now, and we are now dismantling programs and services that our state is going to regret losing -- after it's too late.

And this is happening in a state that understands research and has traditionally supported research. As you might assume, state support for agricultural research has always been strong. Likewise, in the Health Sciences, legislators have long been proud of Minnesota's leadership role, and they have taken actions to develop and sustain that leadership. Most recently, Minnesota legislators have been willing to make some rather speculative investments in energy-related research. The result is some most exciting research into alternative energy sources and the emergence of the University of Minnesota as the world leader in the field of earth-sheltered and underground space utilization. Our state, however, cannot do much more.

One important point often disregarded in discussions of who can or should pay for research investments is the absolute need to avoid the fragmentation of the research enterprise. This country has had and must maintain a broad, multi-disciplinary research program, with maximum communication and cooperation among the researchers. Shifting research sponsorship from the federal government to the private sector and the state governments almost inevitably will lead to an over-emphasis on applied research with immediate economic development implications and less communication among the nation's researchers. The federal government has developed a proper role that minimizes these problems, and it must be maintained.

Even at the federal level, however, we have seen an increasing tendency to support the quick and dramatic technological projects. Research in the social sciences, the behavioral sciences, and the humanities has been taking it on the chin lately. I know these are the areas where you get the flak from constituents who wonder why in the world their taxes are being spent for projects they see as flaky. I have a rejoinder that I would suggest for you. Ask those constituents to think of major American problems that are mainly attributable to a lack of knowledge in hard science and technology. There are some, primarily in the areas of environmental pollution, energy sources, and, to some extent, productivity. Then list some of the other problems we have been grappling with lately, and see what kinds of knowledge we have really been lacking. We have invested billions of dollars in the problems of urban America; the principal problem is that we have had virtually no knowledge base. We do not know -- and we have not known -- much more than gut-level impressions of the problems and the solutions. We got ourselves involved in a disastrous war in Southeast Asia, and it certainly was not a lack of hard science that kept us in that mess. Our ignorance in the social sciences did. We are now watching huge investments in military hard science, and at the same time, we are struggling to keep an already inadequate budget for international education efforts that just might eliminate or reduce the need for all that hardware.

We are trying to restore the importance of the family, improve education, and enhance the quality of life, and we know precious little beyond the common sense that happens to be popular at the moment. We envy Japanese productivity, but we seem to have precious little hard information, and a popular psychology book becomes a best-seller. Finally, the entire federal budget issue hangs on an economic theory and potential public responses to it. Even those most directly identified with it admit that we know very little from economic or behavioral research, and the characterization of it as a "riverboat gamble" has summed it up well. We don't even know enough to understand the odds.

Mr. Chairman, this country -- as a nation -- needs research, and it needs healthy research universities. We can afford it, because we cannot afford not to have it. Legislative leaders have known this and have been willing to stick their necks out when research spending obviously did not command the public's attention and active support. Educators in my institution and across the country have become far more aggressive in communicating the value of research to the general public. I hope we can all continue these efforts, because if it works out that America loses its scientific strength, our constituents will be unforgiving, and they will be right.

Thank you again for listening.

Mr. **Flippo**. Thank you very much for a very thoughtful and outstanding statement, Doctor.

Our last witness today is Dr. Norman Hackerman, president of Rice University. We are very pleased to have you with us. Please feel free to summarize and we will proceed.

Dr. Magrath, I thought that was an interesting statement on the paranoid. Someone else said that just because you are paranoid does not mean they are not out to get you.

Please go ahead.

STATEMENT OF DR. NORMAN C. HACKERMAN, PRESIDENT, RICE UNIVERSITY, HOUSTON, TEXAS AND FORMER CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. **Hackerman**. Mr. Chairman, members of the committee:

I am pleased to be here. I want you to know that I represent no one but myself and my experience.

I may well come in conflict with my colleagues in what I have to say but I won't be surprised if I come out with the same conclusions.

I do not agree, for example, with what President Magrath said about the strength of science at the present time but I will develop that shortly.

I read Dr. Keyworth's testimony and quite a lot of the other testimony that has been given before this committee and I have read Dr. Bloustein's and I have heard these others and I see the classical problem of the purity of policy and the pragmatic pull of demands and needs.

Indeed, I should like to try to develop a way in which one can regard science and research perhaps a little differently than it has been regarded so far. In view of the fact that this committee's title is Science and Technology, I am quite certain that that is the case.

Science is a vital first step to technology and technology is obviously the step to use. It may surprise you to learn that not everybody believes that, that not everybody believes that science is a vital first step, not even among scientists and engineers. But I would say that if one took a poll it would be overwhelmingly accepted that science is a vital first step.

Furthermore, science is a universal phenomenon. It does not belong to any nation. It is timeless, hence, what we don't know today does not perish. On the other hand, scientists and engineers are national and are timely and do not persist.

These two things are very important to what I have to say but first I want to tell you that science is very active at the present time and in my opinion has never been better than it is right now on February 4, 1982. That is the point of conflict I have with my distinguished colleague.

The fact is that we are now more productive and more thoughtful and more understanding of nature than we have ever been. If one looks at the research output in the journals you will find that it is burgeoning.

There are more people contributing. They are contributing with more incisive instrumentation than they have ever had. In fact, you can see further into nature than we have ever seen. You can see so far into nature now that what started diverging following Newton has now begun converging again. Science is converging.

The capacity to do multidisciplinary thinking, as the buzz word goes, in matters of nature has improved tremendously in the last 20 years. We could not even approach the carbon dioxide problem years ago. We could not approach the questions of oceans, the bottoms of the oceans, the way the tectonic plates move, the nature of molecules, the accumulation of atoms for various short periods of time. We could not do that. Now we can.

So, the reduction in innovation and productivity is really not a function of the low state of science. In this case I agree very wholeheartedly with President Magrath. It is a function of something other than that.

Now that would say, if science is in such good shape why don't we forget about it? Why don't we just let it rock along while we solve some other problems?

I think the important thing is the continuity of the stream of scientists and engineers which is one of the highly valued outputs of our system of support of science in this country.

If, indeed, science is timeless or we could get it from some other source, then I guess it might be hard to argue against the reduction and its support. But it is the national value of the scientists and engineers that is important.

And in our system, we produce both science and scientists and engineers simultaneously. And that, I think, is the thing that should not be allowed to disintegrate.

Now, I have separated science and technology and I think in another forum could make a very strong case for that. I would now like to ask you to separate research and development.

We have the general habit of systematizing on the basis that the more things you include in the package, the better you understand the system, the bigger the model the better.

I would like to tell you that research dollars, historically, have never been simple functions of research and development dollars. R. & D. can go up or down and R. can go down or up at the same time.

I urge this committee, if they accept the importance of science per se, to consider the value of looking at research dollars rather than R. & D. dollars.

This is not to denigrate development, not at all. This is to say that while there is coupling, the coupling between the two is fluid, not direct. And in order to get development for technology in the future, we require broad support of science in the present, broad, persistent support of science.

Peripatetic, oscillatory support is really of little value. It is not a matter of the expectation of the scientist or anything else like that. It is a matter of the value of consistent consideration of the problems that nature faces us with. I think you have to recognize how successful our system has been.

There are those who would point to the French system of the CNRS laboratories or the Soviet system of the laboratories of the academy and say that in those two political systems it is easier to direct research than it is in our arrangement. I presume that is right.

But the point is you don't want to direct research. You want to direct development but not research. Research is something that is much more stochastic. It is an area in which one should follow his or her nose. It is an area where you don't simply say I don't understand that but I don't have time to fiddle with it. The main requirement is objectivity.

In fact, the good scientific developments of the past have always been serendipitous in part and they continue to be. So I repeat that the one thing this committee might do is to consider looking at research budgets rather than research and development budgets if it is interested seriously in the continued strength and viability of U.S. science.

Now, I believe it is perfectly legitimate to use pooled money, tax money, for the support of science. This is so because it produces the scientists and engineers which are, themselves, the strength that helped protect the health, helped provide the security, and helped improve the economy of the country.

That sounds almost political, and I suppose it is in a sense. But the fact is there are economists who believe that the country is very dependent on good technology and I believe good technology is dependent on science.

Science cannot be done without scientists and engineers and the scientists come out of the universities so it becomes important to make sure that the universities do not become any more debilitated than necessary.

My friends here won't love me for this but we university presidents have, unfortunately, developed a habit of looking for other places to blame for our problems. For example, in instrumentation, library books or whatnot. In fact, we are the ones that are responsible. But perhaps that is for a different committee.

At any rate, I would like to make the point to you that persistent support of science with its concomitant stream of scientists and engineers is what this committee ought to be concerned about in terms of one part of its title.

There may be a critical lower limit below which the science system won't function. I really don't know if that is true or not but if so it ought to be determined. It may be that you can stretch out and not do any permanent damage but that, again, is something that is not inherent understanding.

I believe that the economic experiment that is being tried now with such theory as it is based on, probably deserves to be tried. At least the majority of the people in the country seem to want it.

In that system, we, the scientists and educators, should be as prepared as anybody else, perhaps more so, to take whatever problems it gives us and try to handle them.

What I have tried to express to you is the fact that science should have a very high priority in the scheme of things in the country and that if you see it the same way then you will give it high priority. And if you give us high priority, and if Congress does the same then whatever we get out of that process is what we have to be willing to make good use of.

I am perfectly willing to abide by the proposition that there is no future without a present. And, therefore, you have to try to solve the present problems. But you would find very few people, if any, who would be willing to abandon the future.

And if you are not willing to abandon the future, if you think there is some value in the future, then certainly science must have a very high priority. In all of this I have not talked about engineering problems nor about instrumentation problems or other current conventional topics, and I don't intend to.

The only other thing I would like to propose is that once you have determined that priority and provided the support, you really ought to let it be with the scientist and engineer to determine the allocation of that support. In this regard I am in agreement with President Magrath's statement on social science. In fact, I have a long statement on that point which I shall not use. In capsule the one thing we are not ignorant in is how people behave and how organizations behave and the offsprings of those; that is are economics and political science.

Yet, for some reason, Federal support of those areas seems to be, not only not forthcoming but to induce rather aberrant behavior in focusing on the kinds of problems that social sciences are supposed to encompass.

I simply want to say again, the distribution, the allocation, really ought to be more in the hands of those who do it and in the hands of those who support it.

Thank you, Mr. Chairman.

Mr. **Flippo**. Thank you very much for a very thought-provoking statement. You made some outstanding points. Thank you for that.

If I might speak for just a moment and I don't want you to think that my statements represent the thinking of the committee necessarily. I am speaking as one member of the committee and other members of the committee can express themselves as they see fit. But it seems to me that at this period of time, when we are facing budget cuts, that it does give the committee an opportunity to examine the entire area of research and technology development in the country and to ask some questions about it.

First of all, if we approach our budget difficulties from a point of view of across-the-board cuts, are we saying that all Federal expenditures have the same value or are some Federal expenditures a part of the problem and some a part of the solution. Science fits into those categories and those are certainly some questions that need to be examined.

It struck me that as these hearings have taken place, that an aspect of these hearings is that we have on the one side an administration whose position is spelled out and whose spokesman is Dr. Keyworth. He has a position in regard to this.

It seems that other academic institutions, you might say, established university communities, seem to have a different viewpoint. The message that I hear coming through from most of our witnesses is that we need more money, not less money.

And the message that I hear coming from Dr. Keyworth is that, well, what are our goals, what have we been spending our Federal research dollar on? Is there research going on that could be eliminated without causing us severe difficulties? The committee hearings, I think, have provided a forum for that debate and I think it has been pursued vigorously.

The questions that come to my mind is this, is our present structure for conducting research and research and development, technology and development, the ideal structure? Has it changed recently? Do we anticipate changes in the future? How should it change? When was the last time we had a national study on what our priorities should be in science, since it said that we can no longer accomplish all those things that we can think of to accomplish? Is there a precedence in the past? Have there been national studies in the last 40 years that attempted to identify those priorities?

When we talk about our present structure and should that be modified, from my point of view, this committee is obligated to look at that and see what is going on. One of the things that I see is a significant concentration of Federal funds in various institutions. As you have very adequately pointed out, should that be changed?

You have made some very strong cases that the reason for doing research is to accomplish some social good and I assume that includes economics. I think you could look around the Nation and see that we have significant economic activity associated with the research and development efforts.

I think the committee legitimately should look at whether or not we ought to continue that method or is there some other method more appropriate. And in these changing times is it appropriate to look at matching funds as you addressed very eloquently, I thought.

If a State wants to develop in some particular area, would it be appropriate for us to look at, perhaps, some matching funds from States in development? I know in some of the programs that we have had where we were trying to establish regional centers of excellence, the matching funds concept was utilized to some extend.

Well, there are always more questions raised than we have answers to and your perspective and your insight is extremely helpful.

Would any member of the panel care to comment on any aspect of those observations?

Dr. HACKERMAN. Yes, I would.

Mr. FLIPPO. Feel free to do so.

Dr. HACKERMAN. I think it is true that Dr. Keyworth's point was not so much that the budget had to be reduced but that was some bad science being supported. Not all the science being supported was good. That is not an improper statement.

I don't think there is any doubt that there is poor activity in any field of endeavor. The problem is that he may have been talking about areas of science and that I think is wrong.

If he is talking about individual projects of less quality, I would have no complaint with that. But fields of science are, I think, much more difficult to deal with.

I know that many people don't believe in the taxonomic approach to biology. By the way, I am not a biologist, I am not a social scientist, I am a chemist.

Taxonomy has been in disfavor for a long time but it seems to be returning to some favor. People have new ways of looking at groupings, new ideas have fallen out of these groupings and regroupings.

So I would say that it is a very legitimate point of view not to look in terms of budget reduction but are you supporting the right kinds of things and I would counter that with just the one proposition I tried to make earlier.

It is not so much the science we get as the scientists and engineers that are important because they are the ones who are going to translate for us. They are the ones who are going to convert science to technology and technology to use as well as confront our general ignorance of nature.

Mr. **Flippo**. Thank you. Doctor, please go right ahead.

Dr. **Magrath**. Thank you.

I would like to comment, if I might, Mr. Flippo.

You really raise, as you very well appreciate, I am sure, questions that could form the basis for a national study and we could spend endless hours addressing them because they are very significant ones.

Let me try to make a few comments.

I must say, Dr. Hackerman, we agree and disagree in part. I can document and I will document that our instrumentation at the University of Minnesota is in serious trouble, so are our libraries.

I can also document that to the best of my ability and this is a point that Dr. Bloustein made too, I have tried to set priorities and make very tough internal judgments, as a number of us have. There is no point in crying and wailing.

We have to deal with reality and adjust to it and we are all, I think, appropriately charged with doing that.

I agree very much with Dr. Hackerman's comment that we need to think in terms of a separation of research and development. We use those two words almost as one and there are important issues that I think need to be addressed by this committee and by all of us.

I have a couple of basic points beyond that that I would like to make. First, by far and by large, our United States has done pretty well in science, particularly since World War II. I hate to see a winning combination taken apart and I believe that the record shows that that is happening.

I think we are pretty good right now in science but I am worried about the future and I am not speaking out of personal self-interest. I am damn concerned, frankly, on what is likely to happen.

The question that you raised, Mr. Congressman, about distribution of support and maintaining high levels of training and education in science throughout the United States raises issues that are significant and practical.

I think they were suggested to some extent in some of the testimony that Frank Press gave. I think it is desirable to have it that way. After all, the national centers of excellence, some of the universities, are in the business of educating and training people that serve American industry and all of our colleges and other developing universities.

On the other hand, it is perfectly legitimate and necessary in terms of regions and States to have regional centers that have their own missions to perform as the president of Florida A. & M. very forcefully indicated.

These things are not in conflict. The conflict happens, of course, if you start reducing dramatically the amount of available support, which is bad for the Nation.

And the point that I would make is we have two levels of decision to make. One is the kinds of decisions that Congress will make within the science and technology budgets. We also have the larger issue of the total Federal budget and how much goes to pure defense and other choices.

I think there are choices to be made and I think the kinds of questions you are raising are the right ones.

Dr. **Bloustein**. Mr. Congressman, if I may address myself to some of the questions you had. Many of the questions you raise we as university presidents address every day in the week.

My colleagues sitting at the table, as I, are faced with some departments in our university that are exceedingly good, some that are bad, some that are marginal, and we have to find a way to distribute dollars.

If any one of us gave all those dollars to the best department we would be killing off a lot of young talent and I think none of us want to do that. We now allocate funds to maintain our current strong departments and encourage the aggressive young faculty in the emerging departments.

So, I think the point you raise is an excellent one but a we already have an answer which we apply on a regular basis in our own allocation of internal funds.

Let me address myself a little bit to Dr. Keyworth's testimony before this committee. I think a great deal of what he said about the size and waste in the funding of science and research budgets may have been true 10 or 15 years ago.

But I don't think that is true anymore. We have gone through a period of decline in budgeting over the last 15-year period. It is not an overnight thing. It is not something that the Reagan administration is coming in and bringing to us.

I agree with Dr. Hackerman. I don't think that Peter Magrath differs. We have the best scientific establishment today that the world knows. We have a much better scientific establishment today than it was 10 years ago. It is extraordinarily better than it was 20 years ago.

My faculty is better than it has ever been It is doing better science than it has ever done.

My question to you is what is going to happen in 5 years? What is going to happen in 10 years with the deterioration that we have seen and the trend lines we have seen?

Dr. Keyworth's point, it seems to me, may be 10 years late. Ten years ago you could have said something the likes of which he said concerning our funding too much science.

As to his point concerning there being bad science, I go back to a point that Dr. Hackerman made. Monday morning quarterbacks can tell you what is bad and good science but you can't tell it very easily while you are playing the game.

Obviously, in some fields, again as Dr. Hackerman said, there are some able people and some people who are not able. but we don't have very good predictability about great science.

If we did it would not be basic science and we would send it somewhere else.

We have to take certain risks and that is one of the reasons why the Federal Government support of basic research is so important. The basic research American universities provide has a payout period over 15 to 20 years and American corporations can't be asked to undertake that risk.

They are in the business of applied and developmental work. They are in technology. We are in basic science and that is why the Federal Government has the most appropriate role.

Second, you asked about matching programs for States. The scientists in Dr. Hackerman's university and Dr. Smith's university and Dr. Magrath's university and my university are not scientists in New Jersey or in Texas or in Florida or in Minnesota.

They are scientists in the world of science They don't see State boundaries and they are not working along State lines. If I go to a senator or an assemblyman of my State for support of a research project, they will support some level of research but they will also recognize that their funding has as much application for Texas, and Florida as it does for New Jersey and, as such, deserves national support.

Now, the State does support some applied research in agriculture and pharmacy and a lot of other fields which are also very vital to us. However, in these areas, there is a direct and immediate application within the State.

So, to go back to your point, on whether it would it make sense to have a Federal and State matching program, I go to Dr. Hackerman's very valuable distinction between science and technology. You might create such a program in technology and applied science but in the basic sciences the States simply don't see their own immediate interest in what the university provides in the basic sciences.

This is a Federal function that goes across State lines because the knowledge involved goes across State lines.

Dr. Hackerman. Mr. Flippo, may I just insert something here?

Mr. Flippo. Yes.

Dr. Hackerman. The fact is the States and private universities do match, they overmatch what the Federal Government puts in support. We pay the faculty's salaries.

Mr. Flippo. Dr. Smith.

Dr. Smith. It occurs to me, Mr. Flippo, that several issues must be dealt with as we look at how involved the Federal Government gets in the whole thing of research.

I would like to try my hand at research specifically because that is what impacts my institution and small institutions across this Nation such as Florida A. & M. University.

As we look at national and international issues, I think it is then that we determine just how much the Federal Government is willing to invest in our universities to help resolve some of these issues.

We take the whole thing of space flight which we are deeply involved in with NASA. That certainly is a national and international issue.

We cannot take the faculty members that we have today and expect them to go on ad infinitum to carry out high quality research to aid this Nation in resolving those problems. We have got to not only have those scientists but we must have some of our graduate students and future scientists even from the secondary school level involved so that, hopefully, the interest will enhance their entrance into this area.

We look at the problems of aging. There is great talk about what should be done in gerontology. Pharmacy, psychology, and other social scientists must get deeply involved and, again, the State is not going to be able to provide the kind of funding that is necessary to carry out great magnitudes of research in those areas and, again, that is a national and international priority that I think the Federal Government must take a look at.

Architecture is another one that is very critical. As we look at problems of energy, again it is not just a State problem. It is a national and international problem and I would just like to cite, if you will bear with me for a moment, something that happened with us. Because of the research that had been done in our school of architecture, the Federal Government came down to Florida and sent a team of our architects over to Somalia to aid in design and development of an entire city that would help to resolve some of the problems of good living for the people of Somalia.

I suggest that as this country continues to reach its tentacles out to the Caribbean very close to us in the south and Africa nations where we have great problems of hunger and starvation as well as some of our European allies who are having some difficulties, this Nation is going to have to look at the kind and quality of research that our colleges and universities can bring to bear on the resolution of these problems.

So I think it is here that you are going to have to delineate the impact that our research will have on the various scenes, whether it is local, State, national or international.

Mr. FLIPPO. Thank you very much.

Mr. Wolpe?

Mr. WOLPE. Thank you, Mr. Chairman.

I would like to pursue the question for a moment of the implications of increased reliance on corporate support for the financing of basic research and development activity at the universities.

I think there are two related questions. One is how accurate and how realistic are the projections that as the Federal Government's contribution to R. & D. declines, certainly the basic research declines, that this will be picked up by the corporate private sector. And the related issue there, of course, is the extent to which the new tax credits that have been built into law will really make a real difference. I mean will it happen?

Second, if it does happen what do you feel about that as presidents of institutions. What are the implications of that additional corporate involvement for the kinds of research development and institutional autonomy of your own universities?

Dr. Magrath?

Dr. MAGRATH. Mr. Wolpe, I would like to comment, if I might, sir.

I do not believe that corporate involvement and contributions address the research investment side, and I don't thnk they will.

I do believe that there are good and productive things that can be done between American corporations and universities and that are being done.

There are risks and there are problems that have to be worked out, but there are ground rules and guidelines that can be developed.

After all, our universities have managed to work out some rather sensitive relationships with the Federal Government, with the Department of Defense and so on and it has worked quite well, generally speaking.

I think it has worked very well and we have developed traditions and usages. I think they can be applied in corporate industrial sectors as they relate to universities. On the tax credit investment I will make a summary comment. I think it is a good and a useful thing but it does not address the basic issue of support for research and, as presently structured, the incentive is sufficient.

That is my opinion. I don't know how my colleagues would respond to that.

Dr. **Hackerman**. I would like to add to that. What the Tax Credit Act may do is to induce corporations to provide funds directly to universities for support of directed research, of activity which has a direct relationship to the companies' own interests.

It is perfectly proper. There is not a thing wrong with that at all but it may reduce the amount of money that the corporations and foundations will have available to support research in the way they have done in the past. That is by simply giving to departments or to universities or to schools and saying do what you can with it. The latter has not been in large amounts individually but has been enough to make a difference. I think that will diminish.

Mr. **Wolpe**. So, in other words, one of the potential implications would be a reduction in funding for basic research and an increase in the amount of directed research.

Dr. **Hackerman**. Yes, but I may be considered biased because I said that before the Tax Credit Act was passed.

Dr. **Bloustein**. Mr. Wolpe, if I may, I think it is slightly more complicated than that. I think some significant portion of the applied research budgets, and development of many corporations will increase in respect to joint ventures with universities. However, this is not going to solve our needs in the basic research programs at our universities.

The tax credit bill, it seems to me, is going to have some significant impact.

We have an example now at Rutgers in the development of a ceramics consortium.

Thirty-five corporations throughout the United States are joining together with us for a cooperative research program. In most instances, it is applied research. It is not the kind of pure research that we need the Federal Government to fund.

I think the strongest impact of the act will be to increase applied research at universities.

Let me go back to two questions. What will the extent be? Minor compared to the need. You are talking about very small dollars compared to the total need nationwide in universities basic research support.

Second, are there dangers? Yes. There may be too much applied research and not enough basic research. There may be dangers that corporations will tend to take advantage of the relationship. But, we have learned to make our way in even more perilous seas in our relationship with various agencies of Government who also, over the years, have put us through the pressure of applied work. We have found a way to handle those pressures and I think we will handle these new business approaches.

Mr. WOLPE. Well, I would like to pursue, if I may, just one last question, Mr. Chairman, and that does relate to the defense piece.

I have a little table here that appeared in the Chemical & Engineering News, January 11, 1982. It summarizes the trends in terms of defense versus nondefense research and development, indicating that in the year 1980 and 1982, if you hold constant 1980 dollars, defense research and development increased by 22.2 percent over the same period nonresearch and development declined by 16.1 percent.

[The material mentioned follows:]

TABLE FROM CHEMICAL & ENGINEERING NEWS MAGAZINE

SUBMITTED BY MR. WOLPE

Funding for defense R&D climbs sharply; other funds decline

				% change		% change constant $ 1980	
$ Millions	1982	1981[a]	1980[b]	1980-82	1981-82	1980-82	1981-82
Defense	$20,596.7	$17,321.6	$14,021.1	46.9%	18.9%	23.7%	9.2%
NASA	5,939.7	5,522.7	5,243.4	13.3	7.6	−4.6	−1.2
Energy	5,503.0	5,867.4	5,768.4	−4.6	−6.2	−19.7	−13.9
Health & Human Services	3,986.8	3,971.1	3,806.0	4.8	0.4	−11.8	−7.8
NSF	970.0	933.6	911.9	6.4	3.9	−10.4	−4.6
USDA	816.0	810.4	714.3	14.2	0.7	−3.8	−7.5
Interior	384.6	417.9	410.2	−6.2	−8.0	−21.1	−15.5
Commerce	304.0	355.1	357.5	−15.0	−14.4	−28.4	−21.4
Transportation	280.6	398.6	397.1	−29.3	−29.6	−40.5	−35.4
EPA	277.0	363.1	341.6	−18.9	−23.7	−31.7	−30.0
Nuclear Regulatory Commission	231.9	216.2	190.8	21.5	7.3	2.3	−1.5
VA	128.2	154.6	135.5	−5.4	−17.1	−20.3	−23.9
AID	118.8	122.7	122.1	−2.7	−3.2	−18.1	−11.1
Education	107.4	129.4	133.8	−19.7	−17.0	−32.4	−23.8
Other	310.6	376.0	500.6	−61.2	−17.4	−47.8	−24.2
TOTAL	$39,955.3	$36,960.4	$33,054.3	20.9%	8.1%	1.8%	−0.7%
Defense R&D[c]	$22,393.0	$18,987.6	$15,430.1	45.1%	17.9%	22.2%	8.3%
Nondefense R&D	$17,562.3	$17,972.8	$17,624.2	−0.4%	−2.3%	−16.1%	−10.3%

a Estimates. b Actual. c Includes DOE defense activities. **Note:** Fiscal years. **Source:** American Association for the Advancement of Science

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My question is: What are the implications for your institutions of this growing concentration of R. & D. dollars within the Defense Department? Are there any specific changes that you foresee and any specific concerns that you have as a consequence of that alteration?

Dr. **Hackerman**. Let me say that that highlights a problem I brought up earlier. The R. & D. budget for the Defense Department did go up. The 6.1 research portion of the budget also increased some but not as much as R. & D. did.

In fact, some of the 6.1 money I think is used in weapons system development which need not be research.

Now, to answer the question directly, to the extent that that money is available for supportive science, it actually does not matter to science how it comes out. I am not making a moral judgment here, Just a pragmatic one.

But to the extent that money was diverted into the Defense Department for research and development and is not used as much for research as it might have been out of some other agency, it will have an effect.

Dr. **Smith**. I think this is one point that I can certainly concur with Dr. Hackerman on. It is at this point that I feel that there is a need to separate research and development.

If you look at the average small university that is involved in research you will find that very little of it is going to be R. & D. It is usually going to be just research.

For example, in our instance, if you were to look at the space age in terms of the future recognizance and combat readiness of this Nation, there might be some applications of the research that we would do in circadian rhythms that impact manpower as it relates to defense. But it is going to take the industrial giants to develop the hardware that would deliver the men who will have been researched upon, if you will, in terms of the impact.

So I suspect that the definite delineation between research and development in this instance is going to be very critical.

Mr. **Wolpe**. Mr. Chairman, may I, without objection, ask that this table be inserted into the record?

Mr. **Flippo**. It certainly will be. Thank you very much.

The distinguished gentleman from New Jersey, Mr. Hollenbeck.

Mr. **Hollenbeck**. Thank you, Mr. Chairman.

Doctor, I missed your testimony. I am sorry. I was down the hall for a while. There is a hearing down there that could use some voices of reason.

I did look at your testimony, though, and turning to equipment you were saying that in terms of modern scientific equipment for research, State funds at our university allow us to replace only about 1 percent of our equipment each year.

Going on through your discussion you mention that industry has complained to you that we, many times, must retrain some of our best students in the use of modern equipment. I am wondering if you are able to comment on the similarity of your circumstances at Rutgers or dissimilarity at Rutgers and the other land-grant colleges and universities across the country?

Dr. **Bloustein**. Well, I think, Mr. Hollenbeck, that, unfortunately, our State has been less generous in its support of basic scientific equipment than many other states in the Nation but it is a matter of degree.

I think all of my colleges in the Nation will agree that our equipment budgets currently are bordering on the totally inadequate. The very cost of equipment in a variety of fields of the hard sciences is beyond our capacity or any single State's capacity.

I also think it is a false economy on the part of the Government which is attempting to stimulate economic development while not supporting sufficiently the needs for modern instrumentation in the very laboratories that will make that industrial development possible.

Mr. **Hollenbeck**. Following on that, and if anyone else wants to comment, just throwing this out and I really don't know whether it is feasible or practical beyond even the logistics of it.

Are any equipment systems, modern systems that you may need available to you or could they be available to you at the national laboratories such as Brookhaven, for example?

Dr. **Bloustein**. We currently have many of our scientists working at Brookhaven. By the way, many of our scientists are working in private labs. A number of our faculty have joint appointments at Bell Labs.

We have visited the wonderful facilities of Bell Labs and we are exploring a lot of other ways that universities and corporations can cooperate.

Mr. **Hollenbeck**. We have unique situations in New Jersey?

Dr. **Bloustein**. Yes, we do. By the way, there are some corporations, who because they cannot use a piece of equipment consistently, will buy the equipment and make a gift of it to the university, recognizing the university has a more consistent long-term use of that piece of equipment. They, in turn, make use of the graduates who have worked on that equipment.

Mr. **Hollenbeck**. Thank you.

Dr. **Magrath**. Mr. Chairman, may I make one comment and then I would appreciate it if I could be excused. I have to catch a plane back to the frozen tundra and meet with some legislators this evening.

On the equipment question, Ed Bloustein answered in a way that is absolutely correctly. There is a point on my mind. About 2 weeks ago I toured some of the development facilities of Honeywell, which is a major high technology firm headquartered in Minnesota; they have been very supportive to universities.

They have given us some money for basic research in a certain general area involving microelectronic activity.

I spent some time with a gentleman who is the vice president for their Solid State Development Division. He has given us a considerable amount of equipment. We get a lot of hand-me-down or secondhand equipment now from the high technology industry.

It is useful but it is the equipment that they are no longer using because it is not at the front line of what is happening. And this gentleman made the point to me that 10 to 15 years ago our colleges and universities were training people who were using equipment that they were just beginning to get. Now it is totally different.

Now, when they get them the people may know how to think and they may be well trained but they have to be trained to that equipment because our equipment, and I am generalizing, but much of our equipment is no longer at the forefront of what is happening.

I think that speaks a little bit to the question you raised.

Mr. HOLLENBECK. I think that ties in with the point you made before with regard to that.

Dr. HACKERMAN. I would like to put something more moderate into the record, if you don't mind.

The fact of the matter is that one can always use better equipment as it rolls off the design line but university laboratories have equipment which is not as good looking but it is just as useful as the equipment that you see in the major industrial laboratories where it is reproduced over and over and over again.

In fact, in the laboratory, one expects the ingenuity of the individual research worker to take the equipment and make it do things that it was not intended to do. And they do it so that it becomes the good equipment of the next year. They can't buy it.

I agree with that. There is no question about that. We don't have the money to buy it and we do get hand-me-downs. But the fact is that the new equipment ideas comes out of the university laboratories. That is an overstatement, of course.

Hewlett Packard would complain about that but the ideas do come out of there. And while I would like the most up-to-date equipment in my research laboratory too, I don't find debilitating the current consortium maybe answering.

Even the fact that we may be using an NMR that is second order equiment does not impair a graduate student in getting used to a new one. One of our big difficulties is that we tend to train people rather than educate them. So I would just as soon that they not be trained simply to step right into a job.

There is, however, a problem in the teaching laboratories. We do have considerable difficulty maintaining what would be called reasonably modern equipment in the teaching laboratories.

But the big problem with equipment in teaching laboratories is maintenance. There universities are really having trouble because it is hard to keep the kind of maintenance people you should have to keep the equipment functioning.

So, one place where we ought to do something about equipment replacement is in the teaching laboratories or better find a way to provide maintenance support.

Mr. FLIPPO. Dr. Smith, did you want to conclude the remarks on that?

Dr. SMITH. Yes, one relates to the concept of not having up-to-date equipment in the laboratory. Oftentimes when representatives from large industry, particularly the high technology industries, visit the campuses, they will make comments about the antiquated equipment that is presently in our research laboratories. And the recommendations come two ways: Get new equipment if it is at all possible or provide release time for faculties to go out to the industries to become familiar with what has been developed out there.

Either of the processes require additional funds that are not normally made available to the institution through normal State appropriations.

So that means also, then, that the need for resources at the Federal level, particularly in those areas where it is a national priority to allow release time for faculty as well as graduated research students to go out into the industry and spend a substantial amount of time to become familiar with the state of the art.

Mr. FLIPPO. Thank you very much.

I just want to express my personal appreciation to the chairman of the full committee for the leadership that he has demonstrated in holding these hearings. I think they will contribute greatly to the debate, and I recognize the distinguished gentleman from Florida.

Mr. FUQUA. Thank you, Chairman Flippo, and I apologize for having been in and out today and I think I explained to you my reasons.

I want to thank all of you and say hello once again to my good friend Dr. Hackerman who I have worked with for many years as the distinguished Chairman of the National Science Board and Walter Smith, who I think is doing an outstanding job at the Florida A. & M. University.

Dr. Bloustein, I appreciate all of you being here and I think this has been very helpful for all of us.

As was pointed out yesterday, our problems in science and technology did not all start with this administration. There has been a trend that has been going on for some time and I think it is getting to be a critical problem now that we are faced with further budget stress, particularly in manpower and instrumentation which all of you have addressed and are very, very familiar with.

I thank you for your help.

Dr. SMITH. Thank you.

Dr. HACKERMAN. Thank you.

[Whereupon, at 12:10 p.m., the committee was adjourned.]